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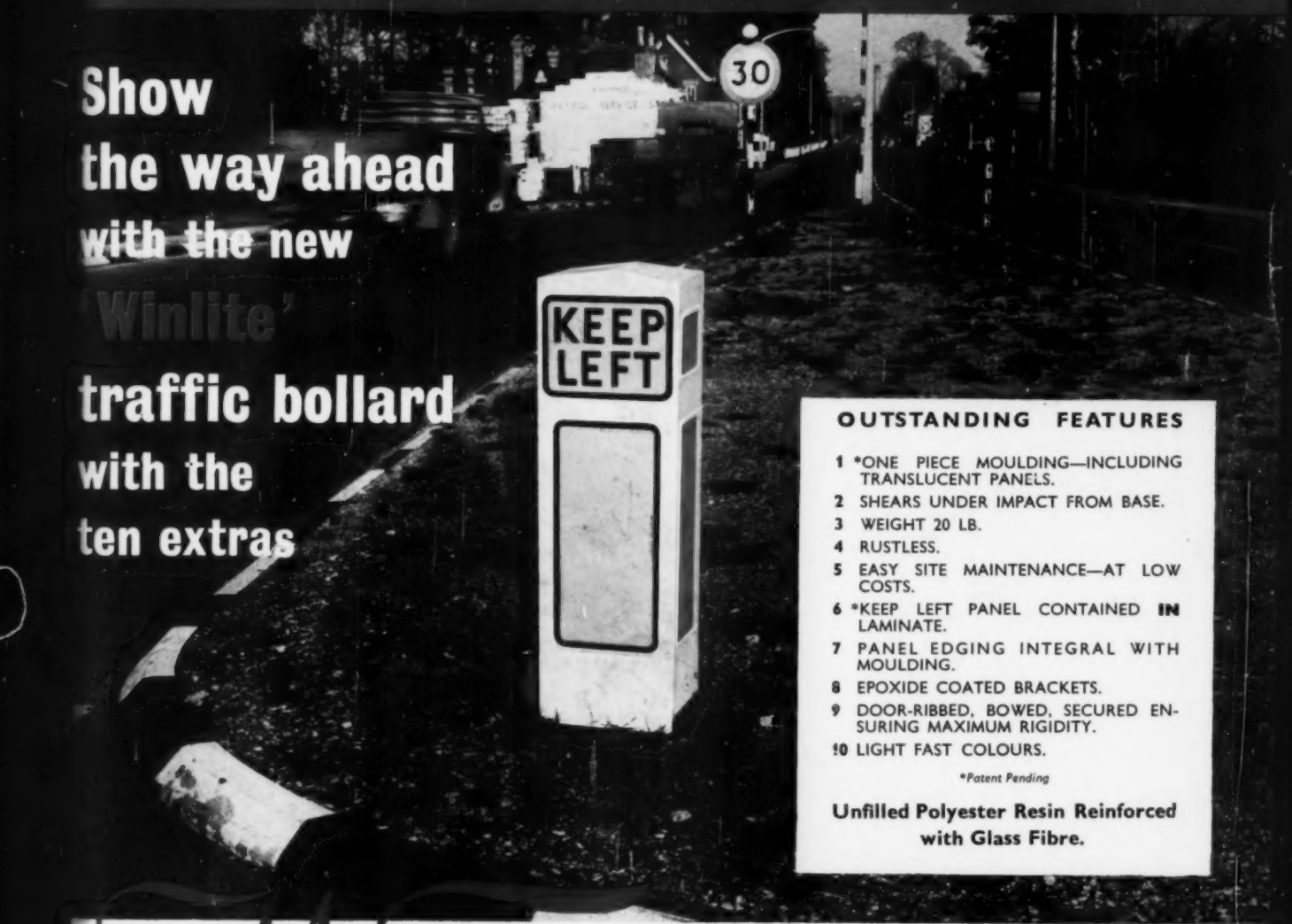

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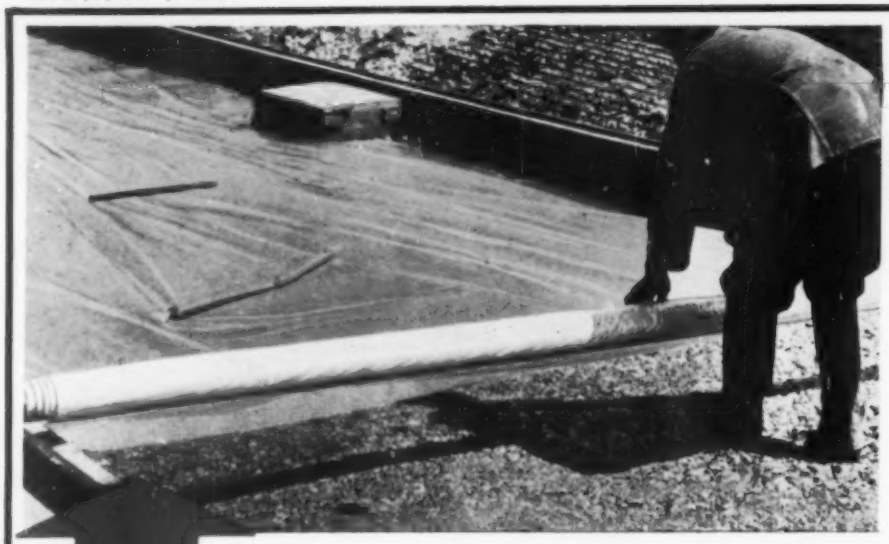

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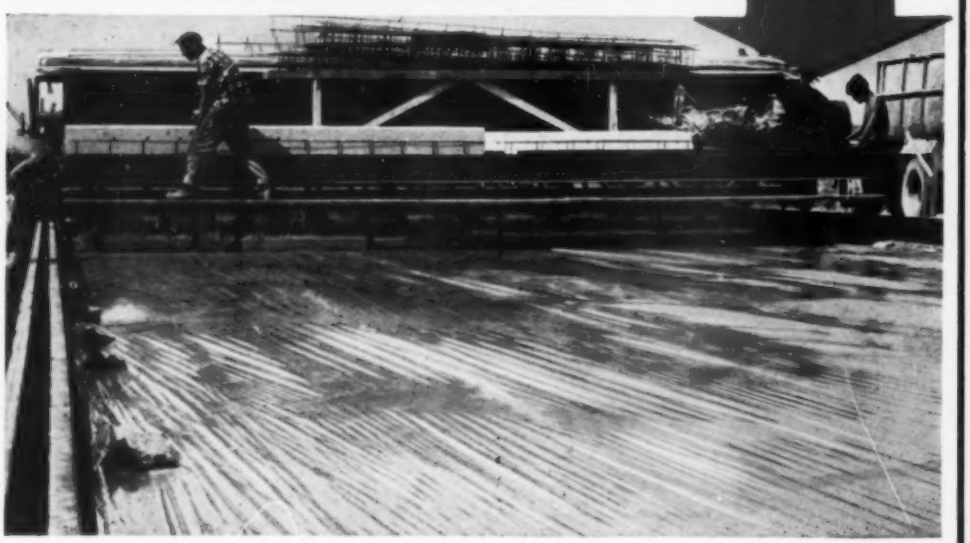

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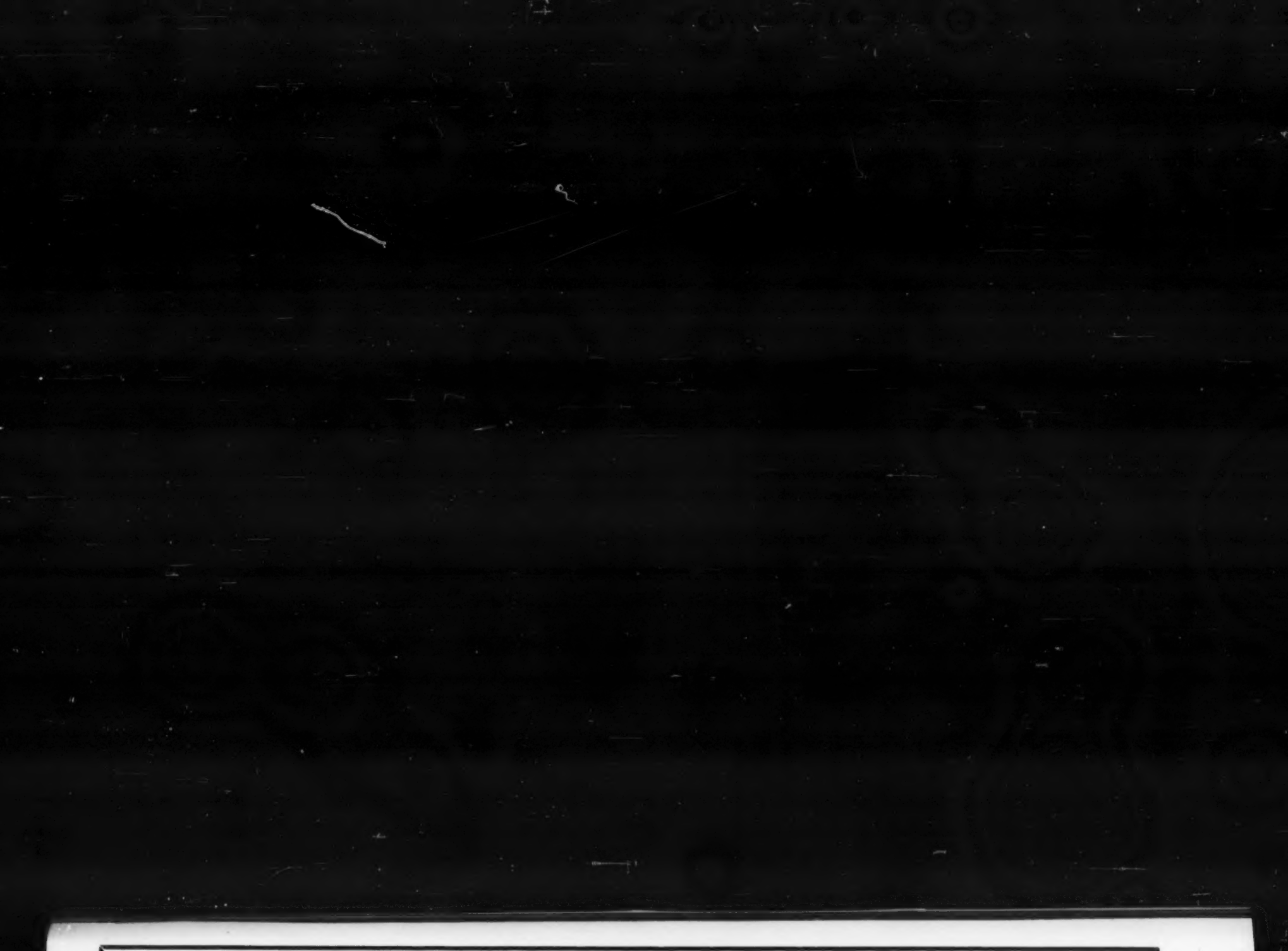

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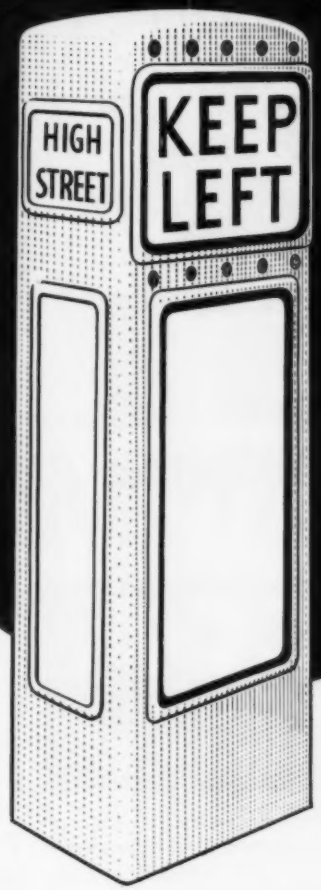

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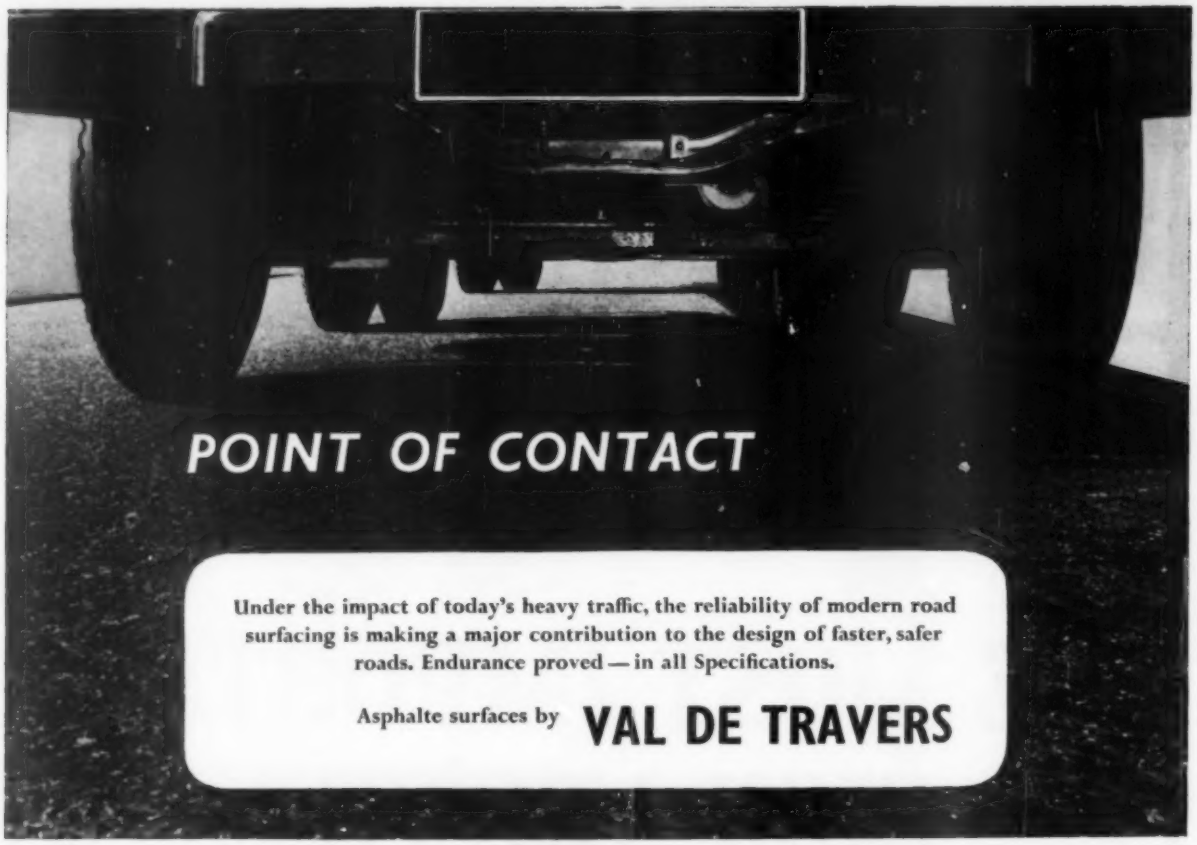

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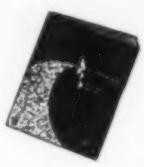

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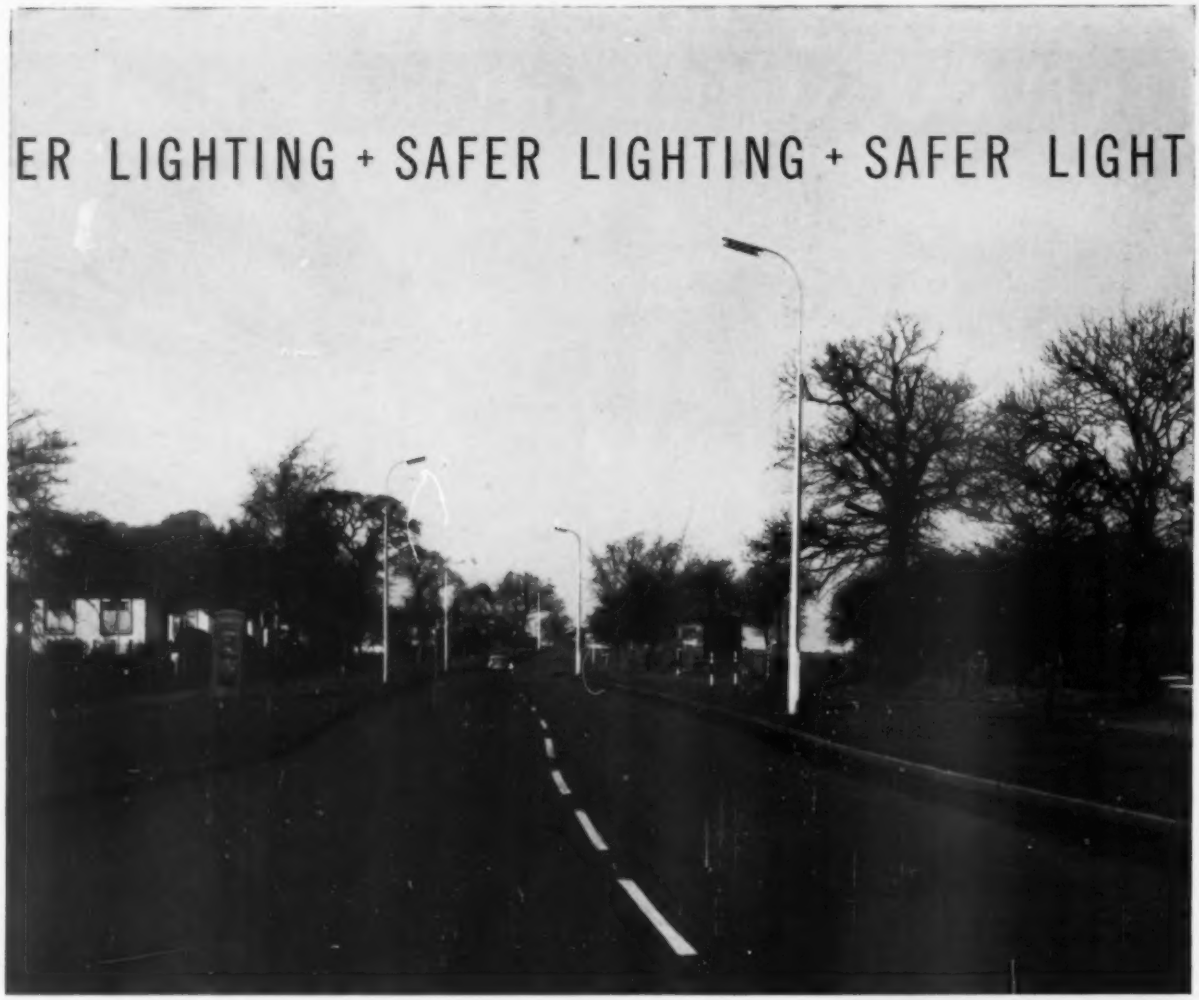

Lighting installation in Fryent Way, Wembley. Photographs reproduced by kind permission of C. W. Steedman Esq., A.M.I.C.E., M.I. Mun.E., M.T.P.I., F.R.S.H., Engineer and Surveyor of the Borough of Wembley.

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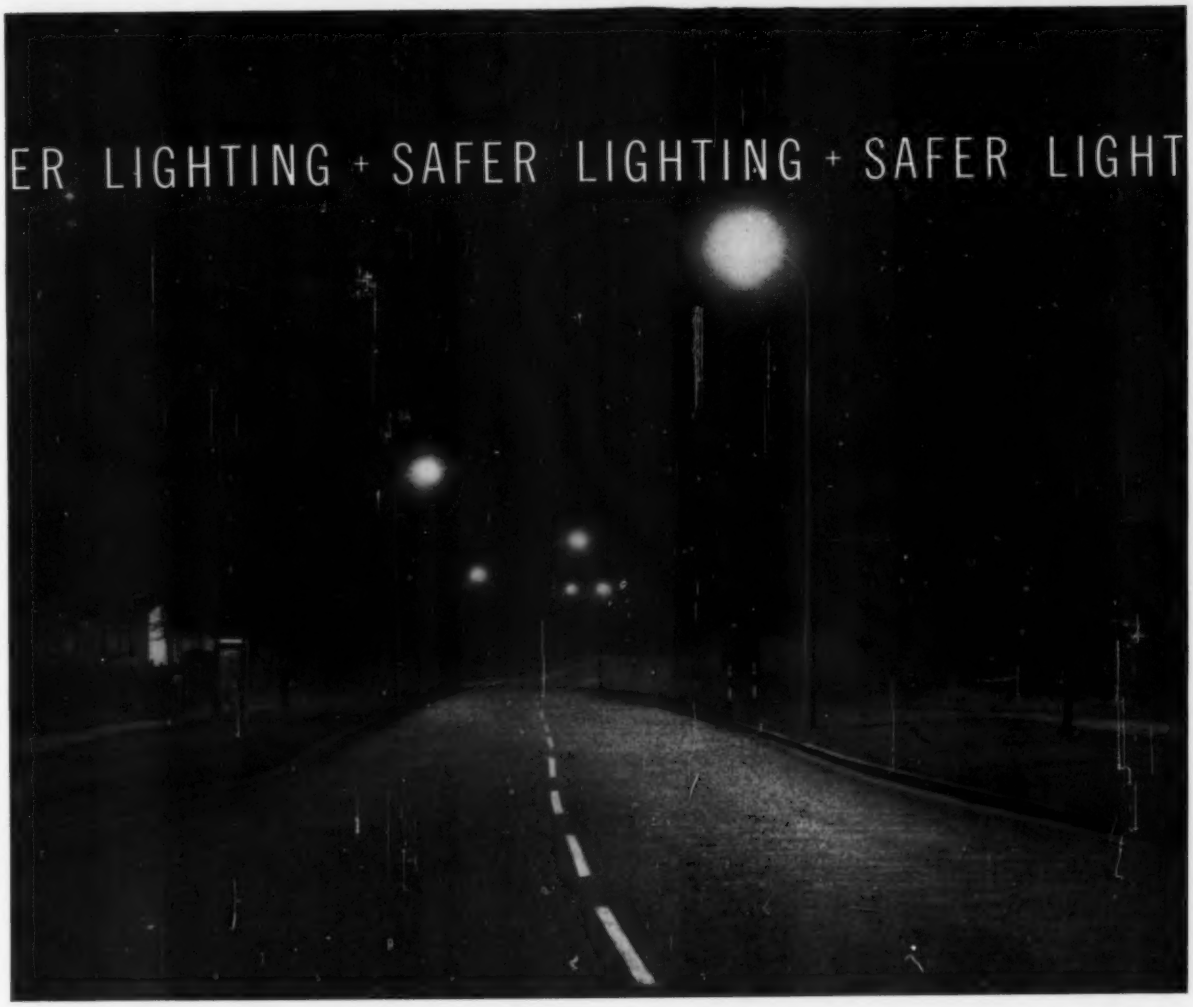

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VOLUME 2 No. 12 APRIL 1961

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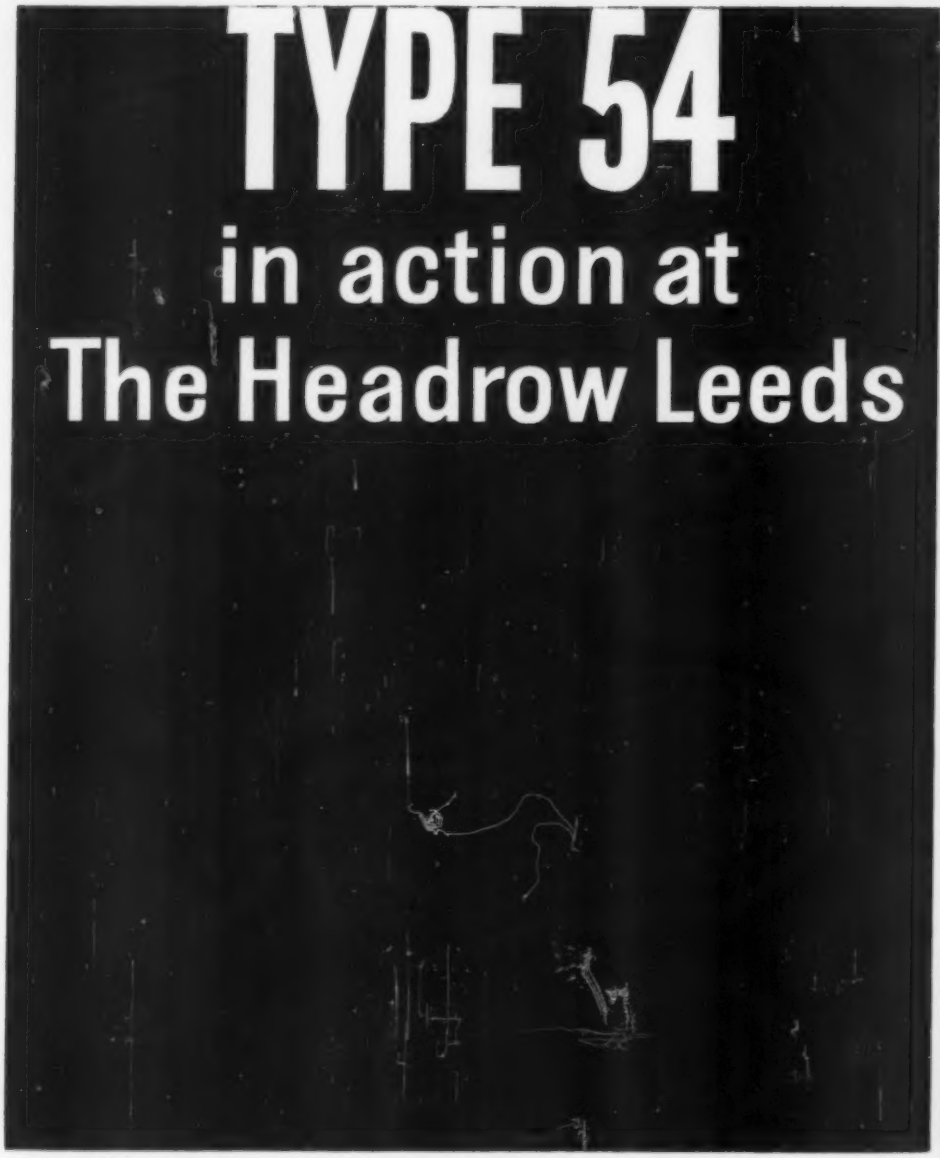

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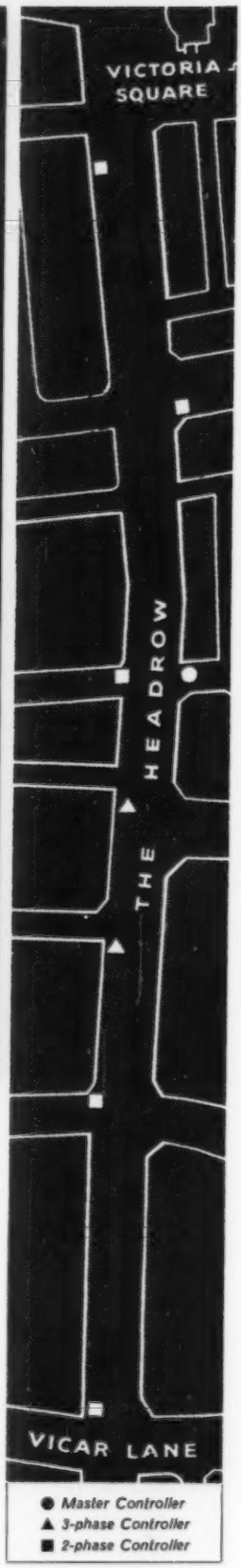

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EDITORIAL OPINION

Roads Expenditure

AS Budget Day approaches, pressure rises for a reduction in motor taxation and increased expenditure on roads. The British Road Federation, for example, is demanding a 30 per cent reduction in taxation on road users, basing its case on the fact that since the last increase in the petrol tax to 2s. 6d. in 1952, the yield has doubled from under £300 million to about £650 million for the financial year just ended, and will exceed £750 million in the next two or three years. It is argued that in view of the overwhelming importance of road transport, the high incidence of this tax is harmful to productivity, our competitive position and to the national economy. It is pointed out that even with a 30 per cent reduction, expenditure on roads could be raised in the next financial year to £200 million and to £250 million subsequently, and still be more than twice covered by taxation. It is, however, a mistake to relate any specific taxation to any particular expenditure, and the case for higher expenditure on roads is so strong in itself that it is quite unnecessary.

The London and Cambridge Economic Service has recently prepared an estimate of expenditure required to bring the roads up to the requisite standard to cope with a doubling of road traffic during the next decade. Its findings are frightening. At present, increasing traffic must be carried on a road network which is already unable to ensure a smooth and safe traffic flow for existing traffic, and current and projected expenditure is falling far short of that needed, not only to make good present deficiencies but to provide for this certain traffic growth. In fact, this latest estimate for other than urban roads, gives roughly 70 per cent of the mileage of trunk roads, one-third of Class 1 and rather over 10 per cent of Class II, as overloaded at the present time. It is estimated that about 15,000 additional lane miles would be required to bring this rural road system up to the standard required by current traffic volumes. Merely to adjust the width to accommodate a doubling in traffic during the next decade, between £1,100 million and £1,700 million of construction would be necessary. When to this is added other capital expenditure necessary to cover essentials to smoother flow and greater safety, the total is raised to some £2,100 million to £2,700 million. Requirements for urban roads are conservatively estimated at £1,000 million, which puts the requirements for road investment alone at £3,100 to £3,700 million during the 1960's. If maintenance is taken into account, the total rises to an average level of some £460 million to £530 million a year. Admittedly, such expenditure is not considered feasible unless the very highest priority be given to securing so great a growth in road expenditure. But these figures reveal afresh the total inadequacy of current expenditure on new construction and major improvement, which is estimated at only £90 million for 1960/1; but the Ministry of Transport estimates for 1961/62 put total expenditure on roads at £136 million. The Chancellor of the Exchequer's responsibility is to decide on priorities and it is his invidious task to judge the merits of expenditure on roads in relation to the benefit gained. The first year's volume of traffic on the London-Birmingham Motorway given in later pages shows a steady growth in its use and, because obvious savings result therefrom, the economic benefit is considerable.

Meanwhile, the Road Research Laboratory has published another invaluable study of road economics in 'An Analysis of the Cost of Road Improvement Schemes' (Technical Paper No. 50, published for D.S.I.R. by H.M.S.O., 1s. 9d. net). This should assist further in assessing the economic benefits derived from new construction, inasmuch as it provides figures based on an actual sample of schemes which can serve as a general basis for economic studies of the benefits in relation to costs. The Laboratory's findings are of considerable interest and in some cases surprising. Thus expressed both in terms of cost per mile or costs per unit area, it was found more expensive to convert three-lane than two-lane single carriageways to dual carriageways, particularly in urban areas. Single carriageways work out comparatively cheaply and, when roadworks alone are considered, it costs approximately the same per mile to add a carriageway to an existing road as it does to build one carriageway of a new dual carriageway road. Little obvious connection was found between cost per unit area and the size of a scheme, except that schemes covering less than 20,000 square feet were more expensive per square foot than the larger schemes. In fact, in general, new dual carriageways are the dearest form of improvement per unit area and new single carriageways the cheapest, except in the case of widening single carriageways in urban areas which are understandably very costly.

Interesting as these findings are, they should not be permitted to over-influence decision as to the form new construction or major improvement should take, particularly in urban areas. There are a great number of factors other than unit costs concerned and the most expensive type of road may, on occasion, bring the greatest economic benefit. In enabling such comparisons to be made, the figures are invaluable, provided always they are related to scientifically collected and analysed traffic data, which alone can provide information as to need, without which no economic assessment on a cost benefit basis can be made with any degree of reasonable accuracy.

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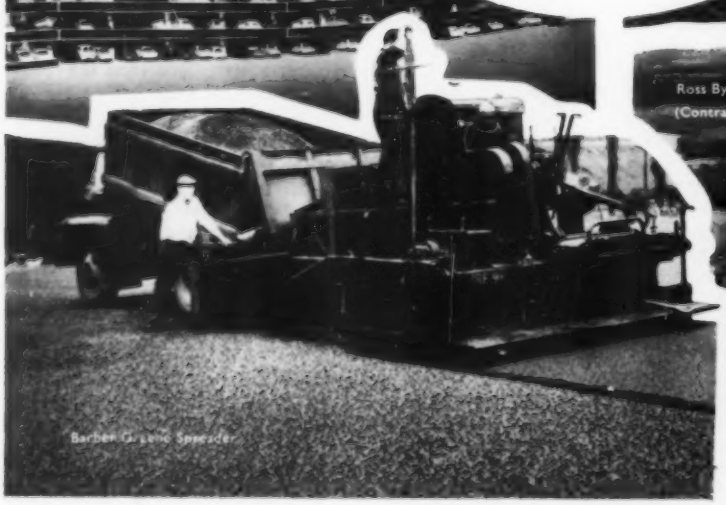

Topics of the Month...

THE final figures for road accidents show last year to have been the worst on record. There were 271,787 personal-injury accidents involving 433,747 vehicles and resulting in 6,970 deaths, 84,443 serious injuries and 256,138 slight injuries. All figures show an increase over 1959, accidents being up by four per cent, total casualties by 4.2 per cent and deaths by 6.9 per cent. The only encouragement that the figures provide is that the accident rate per million vehicle-miles and per number of vehicles licenced dropped slightly. Thus the former was 3.8 compared with 3.9 in 1959 and the latter 29 per 1,000 vehicles against 30 in 1959. On the other hand, the road accident rate per 100,000 of the population, based on the mid-year estimate, rose to 534 compared with 516 in 1959 and the death rate was 13.7 compared with 12.9. This rising toll is tragic enough from the human point of view, but the economic point of view is of equal concern. RoSPA estimates the cost of all road accidents last year at about £229 million. This includes £189 million for deaths and injuries, £19 million for material damage and repair and £21 million for administration. Loss of earnings, hospital treatment, etc. is put at £158 million. The comparable overall total for 1959, similarly based, was £219 million.

In face of these figures it is regrettable that the Minister of Transport was unable to introduce the road safety legislation foreshadowed in the Queen's Speech early in the current Parliamentary Session. As it is, despite the fact that to the extent that it proves controversial it is likely to cut across party lines, in view of the delaying tactics of the Opposition it may now be difficult to get such legislation through before the summer peak traffic volume is reached. Meanwhile, the Parliamentary Secretary's passing reference to the possibility of extending vehicle tests, once the present ones of 10-year old cars are ended, is to be welcomed. Although figures are not yet available for last year for accidents to which defective vehicles contributed, the percentage of tested cars revealing one or more deficiencies indicates the desirability of introducing compulsory annual testing for all vehicles as soon as practicable. This has proved effective in other countries, particularly the United States. Further, while the effectiveness of seat belts in all circumstances may not yet be proved, they are being increasingly accepted and provision is being made by many American car manufacturers to build in equipment to enable them to be fitted to their new models. Determination of standards and greater encouragement of their use could be usefully given by the appropriate authorities here also.

Planning and Transport

THE importance of the inter-relationship of planning and transport has been stressed in two important papers recently presented. The one by Mr. L. C. Hawkins, Member of the London Transport Executive, to the Institute of Transport, and the other by Mr. Christopher Brunner to the Pacific Regional Conference of the International Road Federation. While Mr. Hawkins was speaking mainly of the future of mass transportation, he was clearly of the opinion that its survival in a motorized world depended upon the planning of the future of the city with a view to fitting transport needs to demand and as far as possible influencing that demand so as to maintain its viability. He accepted, therefore, that town and country planning and transport were intimately and inextricably linked. Good planning, he contended, ultimately depended for its success on access and freedom of movement for the people who use the areas planned. This meant that neither should dominate the other but march in step, because the link between planning and transport would effect not only the success of planning but the ability of public transport to function effectively. Mr. Brunner took a similar view and stated that the traffic engineer, the architect and town planner must work as a team. He suggested that many of the present transport problems in cities arose from a lack of planning of the location of industrial and commercial premises and of housing but, although the planning of urban development could ease the traffic problem, it could not solve it. The communication system was the vital link. Mr. Brunner pleaded against an ostrich-like attitude to increasing motorization and for the necessary adjustment to be made so that the changes it brought could be provided for. He considered the choice was between allowing worsening congestion to accelerate the decline of city centres and acceptance of the motor vehicle and rebuilding cities with urban motorways and parking facilities as an integral part of the urban way of life.

Urban Survival and Traffic

THESE two papers appear at an opportune time as on April 10 to 14 a symposium at King's College, Newcastle upon Tyne, is to be devoted to this problem of 'Urban Survival and Traffic.' That it is to be run jointly by the departments of Architecture, Town and Country Planning and Civil Engineering of the University of Durham, indicates acceptance of the interaction of the three activities of land-use planning, architecture and traffic control in urban development. The Roads Campaign Council is acting as co-sponsor of the conference, which is to be presented with a series of papers prepared by distinguished representatives from several countries, including the United States, Germany, South Africa and Spain. Subjects to be discussed include many aspects of both planning and traffic. The former ranges from highway planning in metropolitan areas to urban transportation planning, and from comprehensive redevelopment to factors influencing growth in American cities. Aspects of traffic of particular interest to the traffic engineer to be discussed, include traffic design in urban areas, traffic engineering as an aid to modern town planning, and freeways, parking, radials and ring roads.

FIRST YEAR'S TRAFFIC on M1

by G. R. Green

Road Research Laboratory, Department of Scientific and Industrial Research

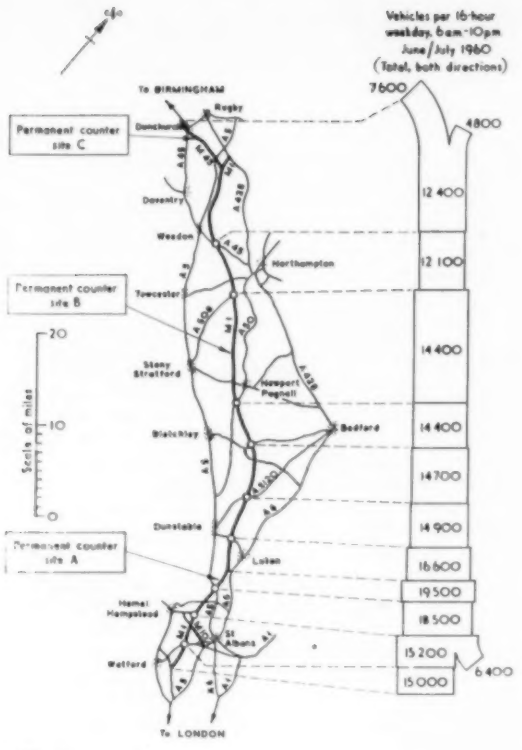

Fig. 1.

The Road Research Laboratory's investigations on the London-Birmingham motorway cover a wide range of topics and a preliminary account of the findings on accidents was published in the December issue of* Traffic Engineering & Control. *This article presents some of the results obtained by automatic traffic counts during the first year of operation of the motorway.

THE month by month variation in traffic flow is given, in Table I, for three positions along the motorway where traffic counters have been operating continuously since the road was opened to traffic in November 1959. Although the changes in traffic flow which are apparent from Table I are partly attributable to normal seasonal variation and normal traffic growth, it seems likely that the overall rise during the year indicates an increasing tendency, on the part of drivers, to transfer from ordinary roads to the motorway. Another factor may also be generated traffic, i.e. new journeys created by the motorway, including extended or more frequent journeys of an earlier type. It is not possible at this stage to assess the relative contribution of these various factors to the growth of traffic on the motorway. This matter is the subject of a special investigation which will be reported later.

Table II, which gives in more detail the traffic at the middle one of the three sites, shows that throughout most of the year the Sunday traffic was appreciably less than the week-day traffic but that in some of the summer months it increased to slightly more than the week-day level. Saturday traffic was always less than Sunday traffic and was considerably less than week-day traffic except in August.

Although continuous records were taken only at the three sites mentioned above, short-term counts were made on all other sections of the motorway. The variation in flow along the motorway is illustrated in Fig. 1 which refers to the average 16-hour week-days in June/July 1960. Fig. 1 shows that the traffic flows are distinctly greater on the parts of the motorway nearest to London.

Estimates of the amount of travel on the motorway since it opened are given in Table III. It is interesting to note that since April of last year a daily average of at least one million vehicle-miles has been attained.

TABLE I

Monthly variation in traffic flow at the three permanent counter sites.

Month	*Vehicles per day* (Total, both directions) (Excluding national holiday periods)*		
	Site A just N. of Friar's Wash interchange (M1/A5)	*Site B just N. of Newport Pagnell service area*	*Site C 3½ miles E. of Dunchurch terminal (M45/A45)*
1959 November	14,500	11,600	7,000
December	14,600	11,500	6,600
1960 January	14,000	10,600	6,100
February	16,000	12,300	6,900
March	17,500	13,600	7,300
April	18,800	14,900	7,500
May	19,900	15,900	8,200
June	21,000	15,900	8,500
July	21,500	16,700	8,900
August	22,000	17,300	8,900
September	23,600	17,900	9,400
October	22,700	17,800	9,100

*24-hour day

TABLE II

Traffic flow on week-days, Saturdays and Sundays at a site just N. of Newport Pagnell service area (Site B)

Month	*Vehicles per day* (Total, both directions) (Excluding national holiday periods)*		
	Week-day	*Saturday*	*Sunday*
1959 November	12,400	8,400	11,200
December	12,300	8,100	9,200
1960 January	11,900	7,500	8,000
February	13,500	8,500	10,100
March	14,500	9,600	12,200
April	16,300	10,800	12,600
May	16,500	12,900	15,500
June	16,500	13,400	14,900
July	17,000	15,800	16,200
August	17,100	17,500	17,900
September	18,100	16,100	18,700
October	18,900	14,400	16,900

*24-hour day

TABLE III

Preliminary estimates of vehicle mileage on the London-Birmingham motorway (including spurs)

Month	*Vehicle-miles in each month (millions)*
1959 November*	21
December*	22
1960 January	22
February	23
March	27
April	30
May	31
June	31
July	34
August	34
September	35
October	35

*71.1 miles of the motorway were opened on November 2, 1959 and a further 2.4 miles (from Aldenham terminal on A41 to Waterdale interchange on A405 in Hertfordshire) was opened on December 21, 1959 making a total of 73.5 miles.

ACKNOWLEDGMENTS

The work described in this article was carried out as part of the research programme of the Road Research Board of the Department of Scientific and Industrial Research. The article is published by permission of the Director of Road Research.

ROAD RESEARCH OPEN DAYS

There will be open days at the Road Research Laboratory establishments at Harmondsworth and Crowthorne on May 3 and 4, 1961. The Road Research track at Crowthorne, Berks, will be open to the public for viewing and demonstrations will be given on various methods of measuring the resistance of road surfaces to skidding; electronic guidance and detection of vehicles; braking and the effect of the unbalance and of high hysteresis tyres; shattering of windscreens; legibility of traffic signs and the reaction of drivers; traffic signals on high-speed roads and at roundabouts; and the use of a computer to minimize delay on a network of roads.

American Report

by Dr. Gilbert Walker
Professor of Commerce, University of Birmingham

Toll Roads in the United States

Fig. 1. Toll Plaza, the New Jersey end of the George Washington Bridge showing how collection is speeded up by increasing the number of lanes to 14 at the entrance to the bridge which carries six lanes of traffic. The directional flows can be changed to meet peak demands.

IN the United States of America, about three and a half million miles of roads of all types of surface—paved, gravelled and earth—are maintained by all the responsible authorities. Until 1916, roads were the sole responsibility of the several states and their subordinate authorities, counties, cities and townships. That year, the Federal Government in Washington assumed liability for part of the expenditure upon a limited mileage of rural post roads. This liability has been steadily increased: 800,000 miles of road are now eligible for grant from federal funds, 250,000 miles are classed as primary roads and 528,000 miles as secondary roads.[1] To federal aid primary roads the Federal Government contribute 45 per cent of expenditure, 30 per cent to federal aid secondary roads, and 25 per cent in addition to the cost of extending federal aid primary and secondary roads into urban areas. Over the decade, 1948 to 1957, $62.3 billion (thousand million) were spent in all. $6.8 billion were the federal share. $42.2 billion fell on the several states and subordinate jurisdictions. Revenues were found from the produce of state and other local taxes ($12.5 billion) and from the taxation of motorists and motor users (highway user imposts, $29.7 billion). During the decade, the balance was made up by tolls ($2 billion) and by loans ($11.4 billion), raised on the credit of state or other local governments. During the ten years, $2 billion were added to expenditure by interest upon this debt and upon that borrowed in earlier years, and $3.7 billion by provision for redemption.

Between 1949 and 1957, federal aid, at the rate of $677 million a year, was wholly inadequate. Total requirements for construction up to 1964 were estimated at $101.8 billion in 1955; and for 20 years thereafter another $5.75 billion a year would be required for maintenance. The several states could not raise any such sum from taxes on vehicles or their users; nor would they raise from general revenues, the share of expenditure for which, in current law, they would become liable. But the levying of tolls on traffic provided prospects of revenue. This was a security which could be pledged and funds which could not be raised in tax could be borrowed upon it. In addition, tolls commended themselves to ideas of equity and to the sense of prudence. The beneficiaries paid, and could be seen to be paying, for the roads which, it was generally agreed, motorists and motor users ought to have. By limiting outlays to receipts collected in tolls, or to the capital sums which could be borrowed on the security of receipts, expenditures on highways could be kept within the revenues put up by those users for whose purposes the road was built and would be maintained.

Finance by borrowing from private investors on the market enables construction and maintenance to be undertaken without apparent burden on national, state and local treasuries. It makes highway

expenditure essentially a venture of private capital. But private investors cannot be expected to advance money except upon prospect of a traffic adequate in density to furnish, in receipts from tolls, sufficient security. As a general rule, such dense traffic is only found in and between the metropolitan areas. Of those routes across the American continent considered in 1939 as possible trans-continental motor highways, it was estimated that by 1965 less than half (45 per cent) would have been able to earn from tolls, at 1 cent a mile for cars and 1½ cents for trucks and buses, a revenue equal to the annual costs of construction and maintenance.[2] More traffic is now foreseen and rates of toll are higher. But costs have risen too and the mileage of interstate highways, which could have been built from the proceeds of tolls, cannot have altered by very much.

Already by 1944, 40,000 miles of federal aid primary highways already had been designated as a national system of interstate highways. In 1954, President Eisenhower appointed an advisory committee to report upon a National Highways Programme; and in 1956, by further amendment to the Federal Aid Highways Act, Congress authorized a grant towards expenditure upon highways of the interstate system 'increased to 90 per cent of the cost thereof' plus a proportion of the remainder, rising to 50 per cent (95 per cent of the whole) to states containing within their boundaries more than five per cent in area of unappropriated public lands and tax-free Indian lands. The interstate system was to be completed by 1969. From 1960 to 1966 the grant was to be appropriated at a rate rising to $2.2 billion. In 1958 this was increased to $2.5 billion, which at $2.80 to the £ amounts to £900 millions a year. There are in this country 8,300 miles of trunk road, about a fifth of the equivalent U.S. highways. One fifth of £900 million exceeds by more than twice the expenditure undertaken by the central government here on the capital improvement of all highways in 1959/60; and by 80 per cent the investment forecast for 1961/62[3].

Money for federal grants in aid of interstate highways is found from a Highways Trust Fund. This Fund was constituted by Title II of the Highway Revenue Act of 1956. It is fed by the proceeds of federal (not state) tax upon fuel, tyres, tread rubber (retreads), sales of trucks and tractors, buses, trailers and semi-trailers and upon heavy vehicles and heavy loads.

History of U.S. Toll Roads

Tolls for the use of a road were first imposed upon motor vehicles by the State of Connecticut in 1939. Funds to finance an extension at the Wilbur Cross Parkway were raised by levy of toll on the Merritt Parkway. These Parkways, as indeed the name implies, were not open to commercial vehicles and toll was paid by those cars only which entered at either end. The Pensylvania Turnpike was the first road to be closed throughout its length except upon payment of toll and open equally to private and commercial vehicles, both to cars and to buses, trucks and vans. Conceived during the nineteen-thirties, construction was undertaken primarily in relief of unemployment. It was begun in 1938 with a

Fig. 2. Map of the Interstate Highways System with the toll roads shown in red.

Fig. 3. A view of the New York Thruway showing diverting eastbound and westbound lanes with the toll free highway on the left.

federal grant of \$29¼ million and an advance from the (federal) Reconstruction Finance Corporation of \$40 million. The road was opened on October 1, 1940 and \$3 million were collected in tolls during the first twelve months; and the Reconstruction Finance Corporation were able to sell their \$40 million of bonds to the public without loss. Revenue from tolls now exceeds the sum of operating expenses and interest; and debt is being redeemed before it is due 'entirely out of the tolls paid by those who use the road'.[4] The toll roads next to be built were the Maine Turnpike, from the state line to Augusta, Me., and the Eastern New Hampshire 'Pike to connect the Maine Turnpike with Massachusetts and, through that state, with the highway systems and inhabitants of New England and New York. Traffic in Maine is seasonal, confined mainly to private cars driven to and from holiday resorts along the coast. The New Jersey Turnpike, opened in 1952, joins the two great metropolitan areas of New York and Philadelphia and, in the course of its 132 miles, passes the most important towns in a densely populated and heavily industrialized state. It carries throughout the year, day and night, an immense traffic in private cars, buses and trucks.

The New Jersey 'Pike was followed in the East by the New York Thruway and, in the West, by a toll-road between Denver and Boulder, Colorado. There were, by December 1958, 22 toll roads in 20 states of the Union, with a combined length of well over 3,000 miles. Toll roads between New York and Chicago are directly connected: for nearly 1,000 miles one can drive on toll roads all the way. The cost in tolls for a private car was in 1960 \$11.50, and for an articulated vehicle, the tractor and semi-trailer of the type commonly seen on the roads of the U.S.A., \$30.60. Table I lists the toll roads open in 1958. Table II gives some examples of tolls charged.

TABLE II

Toll Road or Tunnel	*Automobile*	*Tractor and semi-trailer*
	\$	\$
Holland or Lincoln Tunnel	.50	1.00
New Jersey Turnpike	1.35	3.45
Pennsylvania Turnpike	3.90	11.95
Ohio Turnpike	3.50	8.00
Indiana: East-West Toll Road	2.00	5.60
Chicago: Calumet Skyway	.25	.60
Manhattan-Chicago	11.50	30.60

Table III gives details of the financial results of the turnpikes for the 10-year period 1949-58.

Toll roads, with the exceptions of the Merritt Parkway, Pennsylvania, Maine and New Hampshire Eastern Turnpikes—had by 1960 been opened for less than a decade. Settled conclusions cannot, therefore, yet be reached about the rates of remuneration earned upon the capital investment. However, on the record of the 10 years to 1958, only four of the turnpikes (excluding the Merritt Parkway not, in any case, built as one) have taken in tolls and other receipts an income greater than the sum of outgoings for maintenance, operation and police. For three of these—the New Jersey, New Hampshire Eastern and Pennsylvania Turnpikes, there are good reasons. The New Jersey Turnpike carries a traffic denser by far than any other. The New Hampshire Eastern connects Maine, a popular holiday area, with the heavily populated states of New England and New York. The Pennsylvania Turnpike carries not only a considerable traffic in commercial vehicles, but also

TABLE I

Turnpikes in the U.S.A.—1958

Date opened	*Length (miles)*	*Capital cost* \$000	*Name of Facility*		*Vehicles a day*	*Traffic density a year* 000	*Vehicle miles a mile of road per annum* 000
1/52	17.3	—	Denver-Boulder	(Colo.)	5,744	36,268	2,096
1/57	110.0	74,000	Sunshine State Parkway	(Fla.)	4,154	166,770	1,516
11/58	187.1	92,335	Illinois Toll Road	(Ill.)			
8/56	156.0	280,000	East-West Toll Road	(Ind.)	10,323	587,851	3,768
10/56	236.0	160,000	Kansas Turnpike	(Kan.)	2,842	244,726	1,037
8/56	40.0	38,500	Kentucky Turnpike	(Ky.)	5,416	79,079	1,977
12/47	113.2	79,406	Maine Turnpike	(Me.)	5,346	220,907	1,952
5/57	123.0	239,000	Massachusetts Turnpike	(Mass.)	9,784	439,342	3,573
6/50	37.5	6,770	Eastern New Hampshire	(N.H.)	12,596	85,513	2,280
8/57	38.7	—	Central New Hampshire	(N.H.)	5,761	61,001	1,576
11/51	131.7	466,152	New Jersey Turnpike	(N.J.)	25,772	1,238,908	9,407
1/54	174.2	—	Garden State Parkway	(N.J.)	—	—	—
6/54	573.3	1,059,698	New York Thruway	(N.Y.)	9,245	1,934,503	3,374
12/54	241.4	326,000	Ohio Turnpike	(O.)	10,305	907,904	3,761
5/53	88.0	38,714	Turner	(Okla.)	4,965	159,412	1,812
6/57	88.5	68,000	Will Rogers	(Okla.)	3,236	104,518	1,181
10/40	469.8	229,500	Pennsylvania Turnpike	(Pa.)	10,609	1,819,747	3,874
8/57	30.5	58,500	Dallas-Fort Worth	(Tex.)	11,062	123,151	4,038
6/57	34.6	69,000	Richmond-Petersburg	(Va.)	—	—	—
9/54	87.6	—	West Virginia Turnpike	(W.Va.)	3,034	97,016	1,108

Source: Communicated by the U.S. Department of Commerce, Bureau of Public Roads. — indicates not available.

had the good fortune to be built when costs of construction were low. For the fourth, the Denver-Boulder, the writer has no explanation to offer.

Table IV gives the financial results of toll roads in 1959, the last year for which statistics are generally available. Their financial position has been improved substantially on the years before. Fifteen out of nineteen, omitting again the Merritt Parkway, earned from tolls and other receipts, an income greater than the sum of working costs and interest. Another, the Indiana Turnpike, East-West Toll Road, with the addition of income from investments, has realized a surplus after payment of interest. Financially, nevertheless, their success has been modest. The New York Thruway, the longest and, in many respects, the largest of them all, earned from all current receipts, after payment of interest, $12 millions upon a debt outstanding on December 31, 1958, of $800 million. At this rate, it will take 65 years to retire out of income from tolls and other sources the revenue and guaranteed bonds issued by the Thruway Authority.

Toll roads are worked generally by an authority (commission, board of trustees) created by and responsible to the state. Toll resistance, particularly among rural citizens (whose reluctance to pay in their own neighbourhoods has caused some authorities to allow a free use for local journeys on roads otherwise liable to toll) was becoming a factor to be reckoned with, but interest has to be paid punctually and in full. Should receipts from traffic fail, liability for the debt falls on the state. The New York Thruway Authority, conscious of their obligations to bondholders and to the State of New York, soon after the Thruway was opened invited a review of finance. Study disclosed the forbidding prospect that at the rates of toll then being charged, revenue remaining after deduction of the working expenses would fall

Fig. 4. Interchange 29 on the New York Thruway.

short of requirements for interest and redemption of debt in every year from 1958 to 1975, except for 1962[5]. By 1958, revenue from tolls upon passenger cars had exceeded the estimates framed when the Thruway was projected. It was the traffic in trucks which had 'been a distinct disappointment in relation to advance expectations.'[6]

In June 1956, nine months after the opening in October 1955 of the Ohio Turnpike throughout its length, the Turnpike Commission of the State of Ohio, on the advice of traffic and consulting engineers, reduced tolls on heavy trucks in proportions varying from 10 per cent (16,000 lb. laden to 23,000 lb. laden) to 28 per cent (53,000 lb. to 65,000 lb.). Tolls on the two heaviest classes (65,000 lb. to 78,000 lb. and 78,000 lb. to 90,000 lb.) were reduced by very much less, to $18.50 and $26.50 respectively, (15 per cent and 12 per cent), for journeys over the whole length of the turnpike. Two years later, in

TABLE III

Turnpikes in the U.S.A.—Costs and Revenues—1949-1958

Date opened	*Length (miles)*	*Name of Facility*	*Operating surplus*	*Interest*	*Balance*	*Net income from investment*	*Income available for redemption of debt (or deficit to be added to debt)*	$000,000 *Net debt outstanding 31.12.58 due on facility*	*for general highway purposes*
1/52	17.3	Denver-Boulder (Colo.)	2,496	1,420	1,076	113	1,189	5,397	32,530
1/57	110.0	Sunshine State Parkway (Fla.)	2,858	7,859	**5,001**dr.	1,648	**3,353**dr.	69,690	224,684
11/58	187.1	Illinois Toll Road (Ill.)	**406**dr.	51,854	**52,260**dr.	21,367	**30,893**dr.	441,279	448,279
8/56	156.0	East-West Toll Road (Ind.)	16,027	47,493	**31,466**dr.	8,683	**22,783**dr.	280,000	280,000
10/56	236.0	Kansas Turnpike (Kan.)	6,223	22,946	**16,723**dr.	4,521	**12,202**dr.	175,468	175,468
8/56	40.0	Kentucky Turnpike (Ky.)	2,626	5,891	**3,265**dr.	593	**2,672**dr.	37,412	114,141
12/47	113.2	Maine Turnpike (Me.)	14,927	21,067	**6,140**dr.	1,826	**4,314**dr.	78,600	115,902
5/57	123.0	Massachusetts Turnpike (Mass.)	12,164	35,825	**23,661**dr.	7,675	**15,986**dr.	239,000	728,359
6/50	37.5	Eastern New Hampshire (N.H.)	4,348	2,708	1,640	58	1,698	13,780	54,300
8/57	38.7	Central New Hampshire (N.H.)						18,630	
11/51	131.7	New Jersey Turnpike (N.J.)	141,332	99,847	41,485	10,513	51,998	434,177	817,591
1/54	174.2	Garden State Parkway (N.J.)	41,291	49,068	**7,777**dr.	3,383	**4,394**dr.	330,000	
6/54	573.3	New York Thruway (N.Y.)	73,414	97,127	**23,713**dr.	10,907	**12,806**dr.	797,500	1,144,128
12/54	241.4	Ohio Turnpike (O.)	51,806	69,482	**17,676**dr.	6,521	**11,155**dr.	326,000	666,215
5/53	88.0	Turner (Okla.)	13,041	20,419	**7,378**dr.	1,914	**5,464**dr.	101,621	101,621
6/57	88.5	Will Rogers (Okla.)						101621,	101,621
10/40	469.8	Pennsylvania Turnpike (Pa.)	174,143	106,667	67,476	15,872	83,348	428,137	600,425
8/57	30.5	Dallas-Fort Worth (Tex.)	1,208	6,366	**5,158**dr.	1,268	**3,890**dr.	58,500	60,072
6/57	34.6	Richmond-Petersburg (Va.)	321	8/789	**8,468**dr.	3,009	**5,459**dr.	75,150	206,550
9/54	87.6	West Virginia Turnpike (W.Va.)	11,481	29,760	**18,279**dr.	1,249	**17,030**dr.	133,000	206,666
*		Merritt & Wilbur Cross Parkways	33,991	355	33,636	239	—	—	434,705
1/58	126.0	Connecticut Turnpike	5,310	32,890	**27,580**dr.	4,779	**22,801**dr.	397,000	

*Toll imposed in 1939.

Sources: U.S. Department of Commerce, Bureau of Public Roads, Tables SF-3B, SF-4B, SB-2, 1948-1958; Statement of capitalized costs of toll roads—Section 114 of the Federal Aid Highway Act, 1956.

July 1958, tolls on heavy trucks (65,000 lb. to 78,000 lb.) were reduced again, this time by 16 per cent. Collections of revenue increased after the first reduction, as did the number of buses and trucks using the turnpike; and the 'substantial gains' of revenue after the second reduction in July 1958 'reflected the increased business attracted by' the lower rate of toll for that class of traffic.[7]

Traffic in trucks in the United States has not, it seems, increased by as much as was forecast and the demand of commercial users for transits over the toll roads is more elastic than had been foreseen. The task now is to encourage a greater use of toll roads by commercial vehicles. 'Unless new measures are introduced to enable trucking to continue its growth in the face of rising costs and lower (railway) rates, there will probably be a return of some freight from the highways to the railroads.'[8] It is this return which the New York Thruway Authority is now anxious to prevent. Tolls on the Thruway, though not one presumes on trucks, have been raised on the average by three-tenths of one cent a mile. 'Aggressive steps' have been taken 'to sell the advantages . . . of the Thruway' to commercial operators. Initially, and on a view only of returns made to the Bureau of Public Roads, these remedies have already had a measure of success. The small deficit of $1,400,000, feared for 1959, after providing for bond service (interest), has been turned into a large surplus of $10½ millions. Whether this will be continued and trucks regularly induced on to the Thruway in the greater numbers required, both to balance the accounts and to redeem debt in one generation rather than two, remains to be seen in the out-turns of the future.

The Port of New York Authority was constituted by compact between the States of New York and New Jersey early in the nineteen-twenties. Beginning with the Holland Tunnel, a road tunnel between Manhattan and New Jersey opened early in the nineteen-thirties and liable to toll, the Authority has since built the Lincoln Tunnel, the George Washington Bridge, other bridges also liable to toll between Staten Island (N.Y.) and New Jersey, the Eighth Avenue Bus Terminal, truck terminals and the New York International Airport at Idlewild. They have rebuilt or greatly improved airports at Newark and La Guardia and the piers and marine terminals of the harbour. A third tube has been added to the Lincoln Tunnel, the capacity of the George Washington Bridge has been enlarged by the construction of a lower deck and it is now proposed that, jointly with other authorities, a twelve lane two-decker bridge shall be thrown across the entrance to New York Harbour at the Narrows between Brooklyn and Staten Island. All this the Authority has done, without cost to New York State and the State of New Jersey, either out of revenue from tolls and dues or with capital borrowed upon that security.

Toll roads lying along the route of an interstate highway and reaching the required standard can be approved as parts of the interstate system. By one count 1,950 miles and by another 2,102 have already been incorporated. No federal funds may be spent on the construction, reconstruction or improvement of roads, bridges and tunnels subject to toll. Toll roads to qualify for aid will have thus to be freed. At some future date, Congress is to consider whether states should be reimbursed for those stretches of interstate highways, both toll and free, which had been constructed before the Act of 1956.

Revenues accruing to the Highway Trust Fund were quickly exhausted. Congress in 1958, in part as an antidote to recession, relieved for two years the operations of the Fund from those provisions of the Act of 1956 which required a balance in the accounts at the end of each year. The Secretary of Commerce, reporting upon progress concluded in 1959 that 'unless additional funds were made available there could be no new grants for 1961, $500 million only in 1962 and, thereafter, $1.7 to $1.8 billion in place of the $2.5 billions to which annual appropriations had been raised. President Eisenhower, in 1959, asked for an increase of 1½ cents in federal tax on gasoline (petrol). The (Democratic) Congress, agreeing to raise (federal) tax on gasoline from three to four cents, voted for one cent only. They transferred to the Fund one-half of the excise taxes on new automobiles and parts and it was left to the Administration, acting through the Bureau of Public Roads,

TABLE IV

Turnpikes in the U.S.A. Costs and Revenues—1959, $000,000

State	*Name of Facility*	*Operating surplus*	*Interest*	*Balance*	*Net income from investments*	*Debt outstanding 31.12.58*	*Income accruing during the year available for redemption of debt*	*Rate %*
Colo.	Denver-Boulder Turnpike	494	160	334	117	5,397	451	8.4
Fla.	Sunshine State Parkway	3,714	2,239	1,475	201	69,690	1,676	2.4
Ill.	Northern Illinois Toll Highway	10,112	17,586	**7,474**dr.	1,961	441,279	**5,513**dr.	
Ind.	Indiana Turnpike	9,542	9,855	**313**dr.	1,424	280,000	1,111	0.4
Kan.	Kansas Turnpike	4,417	6,134	**1,717**dr.	508	175,468	**1,209**dr.	
Ken.	Kentucky Turnpike	1,466	1,305	161	136	37,412	297	0.8
Me.	Maine Turnpike	3,426	3,162	264	91	78,600	355	0.5
Mass.	Massachusetts Turnpike	8,832	7,887	945	407	239,000	1,352	0.6
N.H.	New Hampshire Turnpike System	1,142	827	315	—	38,080	315	0.8
N.J.	New Jersey Turnpike	27,943	13,876	14067	1,604	434,177	15,671	3.6
N.J.	Garden State Parkway	14,048	9,898	4,150	578	330,000	4,728	1.4
N.Y.	New York Thruway	34,335	23,864	10,471	1,849	797,500	12,328	1.5
Ohio	Ohio Turnpike	17,833	10,707	7,126	476	326,000	7,602	2.3
Okla.	Oklahoma Turnpike System	4,690	3,694	996	273	101,621	1,269	1.2
Penn.	Pennsylvania Turnpike System	27,121	13,220	13,901	1,622	428,137	15,523	3.6
Texas	Dallas-Fort Worth Turnpike	1,844	1,656	188	82	58,500	270	0.4
Va.	Richmond-Petersburg Turnpike	1,944	2,657	**713**dr.	284	75,150	**429**dr.	
West Va.	West Virginia Turnpike	3,164	2,662	502	55	133,000	557	0.4
Conn.	Merritt and Wilbur Cross Parkways	4,075	—	4,075	—	—		
Conn.	Connecticut Turnpike	12,460	16,614	**4,154**dr.	2,236	397,000	**1,918**dr.	

Source: U.S. Department of Commerce. Bureau of Public Roads. Tables SF-3A and SB-2.

to arrange with the states that grants did not fall due at a rate faster than could be maintained from revenues of taxes currently assigned to the Fund. With these easements 'apportionment' could be, and has been made, of $1.8 billion for 1961 and $2.2 billion for 1962.

The cost of completing by 1965 the system of interstate highways to the standards which would be required by the traffic of 1975, had been put on a first view in 1955 at $23.2 billion. In 1958, later and more detailed estimates raised that figure to $41 billion, of which the federal share would be $37 billion. Of these estimates, neither differs in gross from the costings in the latest report to Congress. More traffic is foreseen. Altogether more ambitious minima are being prescribed and Congress has directed that access to all interstate highways shall be limited. No less than 84 per cent of mileage will consist of four-lane divided highways, while 11 per cent in the neighbourhood of towns and large cities will be of six lanes or more. Mileage with only two lanes will be 5 per cent or less. The price of road works has risen since 1955, and there are in fact more miles to be constructed though, by reason of an initial over-estimate, the length in gross is not increased.

The completed mileage of interstate highways by September 30, 1960, was 9,579, 4,235 of which reach standards likely to be demanded by the traffic of 1975; 4,575 miles are under construction and funds have been committed for another 9,993 miles. 'Some form of work was under way or completed on 24,147 miles of the 41,000 mile system, about three fifths of whole.' Analysis of data ascertained in the course of the AASHO Road Test in Illinois cannot be expected before the middle of 1961. But the Congress have now before them the first, second and third progress reports and the final report of the highway cost allocation study presenting 'the results and conclusions of a four-year study of highway costs, of highway user taxes and of the direct and indirect benefits of highways.'[9] The study had been authorized by the Act of 1956. With this assistance, Congress is hoping to determine rates of motor tax which shall assure 'an equitable distribution of the tax burden among the various classes of persons using federal aid highways or otherwise deriving benefits from them.'

The expenses of completing within the time allowed the system of interstate highways is likely, it is now recognized, to exceed by nearly 50 per cent ($12.7 billion) the estimates of cost upon which was framed the legislation governing the Highways Trust Fund in Title II of the Act of 1956. The Administration of President Kennedy have acted already with characteristic dispatch. Convinced of urgency, they have sent to Congress a message asking for another $900 million a year (about £320 million). 'This should be raised by cancelling plans to cut the gasoline tax . . . by increasing taxes on diesel fuels, certain heavy lorries, tyres, inner tubes and rubber used for re-treading'.[10] The move is now with the elected representatives of the people in the Congress of the United States. Prophesy in economic affairs is rash, the more so when economics are bedevilled by politics. But the omens are good. If I may hazard a guess, or rather two, they would be these—first that motorists and motor users in the United States are going to get their interstate highways, built up to standards laid down and in the prescribed time; second, that among them there will be no more toll roads. Tolls, whatever else they may do, impose limits on traffic. Drivers and operators of vehicles who are unwilling to pay do not enter upon roads, bridges and tunnels liable to toll. Tolls in the United States furnished the security on which money could be borrowed for road works when other means of raising funds had failed. States with access to federal funds for 90 per cent of expenditure need no such pledge—unless it should be that states and local authorities are determined to build or improve a road for which there has been no apportionment.

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[1]Factors for use in apportioning funds for the national system of interstate and defence highways p.2, Table A, 85th Congress, 2nd Session.
[2]Toll roads and free roads, H.R. 272, 76th Congress, 1st Session.
[3]Public Investment in Great Britain, Cmd. 1248.
[4]Pennsylvania Turnpike Commission, Report 1959, p.4.
[5]New York State Thruway: Financial results and prospects: Interim Report, December 1958, p. 17: Madigan-Hyland Consulting Engineers, New York.
[6]Ibid, p.7.
[7]Ohio State Turnpike Commission Reports, 1956 and 1960.
[8]New York State Thruway: Financial results and prospects: Interim Report, December 1958, p.11: Madigan-Hyland Consulting Engineers, New York.
[9]85th Congress 1st Session House Document No. 106; 2nd Session No. 334; 86th Congress 1st Session No. 91; 87th Congress 1st Session No. 72.
[10]The Times (London) March 1, 1961.

Fig. 5. A toll free road south of Richfield, Minnesota, showing a grade separated interchange.

Saturation Flow at Light-Controlled Intersections

by Brian Helm, M.Sc.

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THE flow of vehicles in each lane at a light-controlled intersection is interrupted by the stop signal, which results in direct reduction in the continuous capacity of the lane proportionate to the duration of the red period. The loss of flow is modified, however, by the stopping and acceleration characteristics of the stream, which extend the effect of the stop signal. This extension is referred to as 'lost time' and the continuous capacity of each lane is termed 'saturation flow'.

Dr. Webster of the Road Research Laboratory has derived formulae for estimating the optimun setting of traffic signals to give the minimum average delay to vehicles using an intersection.[1] For given conditions and flows, this delay is directly related to the cycle-time of the signals, which is in turn a function of the lost time and saturation flow of the approach road carrying the greater density of traffic during each green phase of the light-cycle. The values of lost time and saturation flow are influenced by the traffic and site conditions and it was to contribute towards the understanding of these variations that researches were conducted into the behaviour of queues of vehicles at light-controlled intersections in North-east England. The results and implications of these studies are reported in this article.

Scope of Studies

A phenomenon of the behaviour of traffic at many intersections is the reluctance of drivers to form more than one line of vehicles on any approach road, except for those vehicles wishing to turn right which queue on the crown of the road without interfering with other traffic. Thirty-two such approach roads to 15 light-controlled intersections in Newcastle upon Tyne and Gateshead were selected and studies made of the behaviour of traffic leaving those roads.

Contrary to the Highway Code, vehicles start to move during the red-amber but are generally unable to enter the intersection until the preceding cross-movement is complete. Thereafter, queues of vehicles accelerate over the cross-road and attain fairly steady rates of discharge which are maintained, during saturated phases, until after the commencement of amber, possibly causing delay to vehicles in the following phase. In order to study this movement fully, observations were made of the acceleration of queues, following the start of red-amber, and of the time interval between the rear ends of vehicles leaving intersections. These were related to the speed of discharge of the major movement of vehicles, measured during saturation flow, and to the geometry of the approach lane in which the stream under study flowed. The latter included the width and gradient of the lane, the distance of the stop line from the intersection, the width of the cross-road and the angles of turn from the approach lane to the outlet arms of junction.

Vehicles were classified according to the four main groups shown in Table I. For the type of intersection studied, vehicles turning right interrupt only the flow across which they turn and these vehicles have, therefore, been considered relative to the hindered stream.

For the purposes of these investigations, field observations were made using a modified typewriter (Fig. 1). A paper tape was fed past the type-head at a constant rate, the platen being driven by a clockwork gramophone motor. As queues left the intersection, code letters were typed on the tape according to the class and turning movement of each vehicle and the interference to which it was subjected. A typical entry on the tape is shown in Figure 2. The use of the modified typewriter, measurements with which were within 1/10 second, enabled the collection

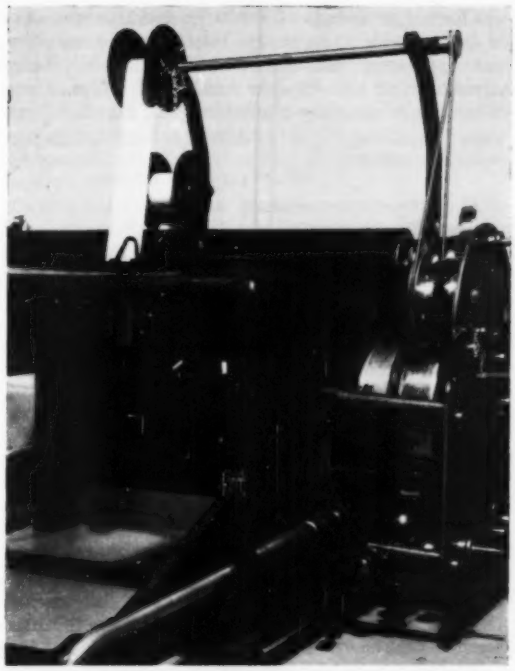

Fig. 1. The back of the modified typewriter, showing the drive to the platen.

Fig. 2 below gives a typical entry on the tape for an unsaturated phase.

Tape	*Symbol represents*
—	Start of red-amber.
t	Last vehicle in cross-flow.
b	Straight-through light vehicle.
h	Straight-through public service vehicle.
d	Left-turning heavy vehicle.
b	Straight-through light vehicle.
x	Opposing right-turning light vehicle.
s	End of saturation flow.
+	Start of red period.

NOTES: Symbols show the time at which the rear end of vehicles left the intersection.
Time measurements were made to the base of symbols.
The tape was fed past the type-head at a constant rate of $1\frac{7}{8}$ feet per minute.
For ease of operation and analysis the keys were arranged to form a block of four rows of three letters: a, b, c; d, e, f; etc.

of data suitable for the analysis both of the characteristics of individual vehicles and of the stream as a whole. The results were averaged for comparative positions within streams and these averages compared between streams of differing properties. In discussing the findings of these studies, which were conducted in 1957-58, it is convenient to use the symbols shown in Table II, which notes the ranges of values encountered. The probability that the equations are representative of the observations is

TABLE I
Classification of Vehicles

Class	*Types of vehicles included*
A. Light Vehicles*	Cars, light vans and motorcycles, where a full vehicle space was used.
B. Heavy Vehicles	Medium and heavy commercial vans and lorries not obviously exceeding the length of a 'bus.
C. Very Heavy Vehicles	Commercial vehicles, including trailers, obviously of greater length than a 'bus.
D. Public Service Vehicles	All 'buses and trolley 'buses, except where there was an overhead crossing of wires in which case queues containing trolley 'buses were not analysed.

*Footnote: The average length of light vehicles was found to be 158 in., 95 per cent of these vehicles having a length of between 138 and 180 in. (Measurements made in 1957).

indicated by the percentage of significance quoted with the equations, higher values indicating a greater certainty.

Although rain was encountered during only seven out of more than three hundred hours of field work, the results obtained during these hours suggested that the behaviour of vehicles was significantly affected by the weather. However, the study of behaviour in wet conditions would require more data than was obtained; in consequence, the analysis was confined to conditions when the road was no more than damp. A further limitation was imposed by the small numbers of heavy and public service vehicles in all but a few of the streams studied and, as a result, only approximate estimates of their effects could be made.

Behaviour of Vehicles in Queues

During the red period, 95 per cent of vehicles stopped with the front bumper within 10 feet of either side of

TABLE II
Symbols used in discussion of results and range of observations.

Symbol	*Representing*	*Range observed*
d_i	Distance of stop line from nearside of cross-road in feet	14-59 ft.
d_o	Distance of stop line from far side of cross-road in feet	47-140 ft.
$d_o - d_i$	Width of cross-road in feet	24-94 ft.
a	Speed of major movement in stream in miles per hour	12-19 m.p.h.
x	Percentage of heavy vehicles.	0-18%
y	Percentage of public service vehicles.	0-19%
H	Percentage of heavy and public service vehicles	0-30%
R	Percentage of opposing right-turning vehicles related to the stream across which they turned	0-23%
P	Percentage of phases subjected to delay caused by cross-traffic	—
g	Gradient at the stop line of the approach and exit roads	Between ±6%

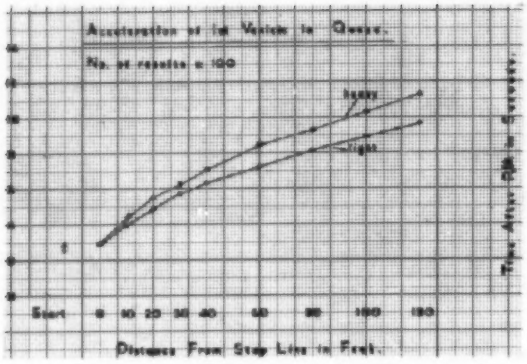

Fig. 3. Typical curve showing the acceleration of the first vehicle in a queue.

the stop line, except at one junction where heavy right-turning movements predominantly passed the line, doubtless in an attempt to turn before the opposing flow commenced. On average, vehicles remained stationary for a further 2.4 seconds after the start of red-amber. Each successive vehicle within the queue started to move 1.5 seconds after the vehicle in front.

The majority of the acceleration away from the stop line was completed within the first 40 feet (Fig. 3), the time taken being influenced by the distance of the stop line from the cross-road. Equation 1 shows this relationship for light vehicles not subjected to interference from the vehicles of the preceding phase. Heavy and public service vehicles took, on average, 10 per cent longer to cover this distance.

Time to cover 40 feet after start of red-amber (light vehicles) = $0.051d_i + 4.1$ seconds (95 per cent significant) . . . Equation 1.

The continued cross-flow of vehicles after the start of red-amber had a marked effect on the time taken by leading vehicles to cross the intersection, the effect being greater over narrow cross roads (Equation 2). (*This effect might be due to one or more of the measurements* d_i, d_o *and* $(d_o - d_i)$ *since these are significantly related for the cases studied. See equation 9 below*).

$$\frac{\text{Time of Delayed Vehicles}}{\text{Time of Undelayed Vehicles}} = 1.23 - 0.0012d_o$$ (98 per cent significant) . . . Equation 2.

Queues of light vehicles were discharged from intersections at steady rates after the exit of the second vehicle (Fig. 4). The time interval between light vehicles during saturation flow was found to be

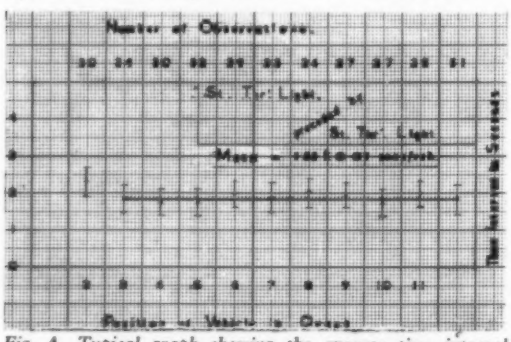

Fig. 4. Typical graph showing the average time interval between vehicles leaving an intersection.

less for higher speeds of discharge and also tended to be less at wide cross-roads. However, this variation was both small and somewhat questionable, being significant at the 80 per cent level only. These relationships are shown graphically in Fig. 5.

Time interval between light vehicles $= 2.75 - 0.0035(d_o - d_i) - 0.042a$ secs. (80, 99 per cent significant) . . . Equation 3.

The larger time interval of the second vehicle, compared with that of the following vehicles, was apparently related to the distance of the stop line from the far side of the cross-road.

Extra time interval of second light vehicle $= 0.17d_o - 1.5$ per cent (95 per cent significant) . . . Equation 4.

It is of interest to note that light vehicles tended to travel at a greater distance from heavy and public service vehicles than from light vehicles and, at low speeds, the time interval was as much as 15 per cent greater. (Equation 5).

Increase in time interval when following heavy & public service vehicles $= 58 - 3.4a$ per cent (98 per cent significant) . . . Equation 5.

As might be expected, heavy and public service vehicles delayed the achievement of saturation flow, the effect being detectable at the outlet of intersections, when these vehicles appeared in the first four places of the queues. During saturation flow, the time intervals of heavy and public service vehicles were respectively 50 and 70 per cent more than for light vehicles; limited data suggested that very heavy vehicles occupied more than twice the time interval of light vehicles.

In contrast with an observed 20 to 30 per cent increase in the time intervals between successive vehicles turning freely from a stream through large

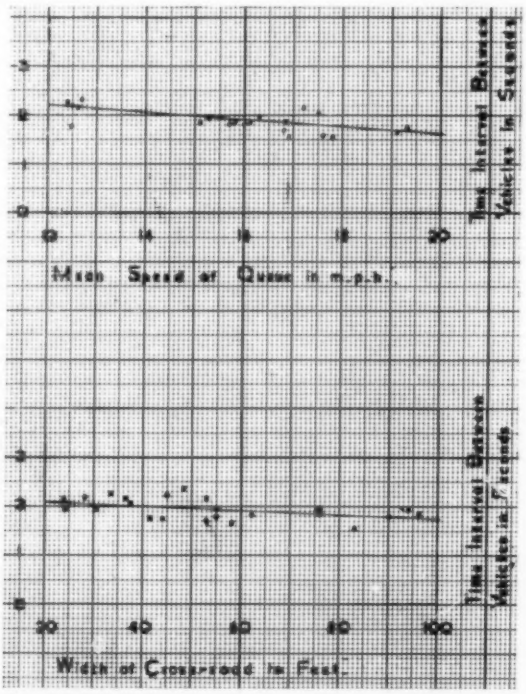

Fig. 5. Variation of mean time interval between light vehicles.

acute angles, one such vehicle in isolation had no significant effect on the rate of discharge, although for obtuse turns of 100 to 120 degrees reductions equivalent to almost one non-turning light vehicle were observed. Heavy vehicles turning through 90 degrees occupied approximately 25 per cent more time interval than if proceeding straight through the junction.

Neither the range of gradients encountered nor the width of lane available to through traffic had a significant effect on any of the above results. However, it should be noted that, in the case of the latter, studies were confined to approach roads from which vehicles streamed in one line.

Saturated Phases

The foregoing analysis indicated certain factors which influence the behaviour of individual vehicles within queues controlled by traffic signals and the repercussions of these factors upon the general flow of traffic was subsequently examined. For this purpose, saturation flow curves were constructed for 15 of the streams of traffic in which a substantial number of phases were saturated. The curves represent the rate of discharge of vehicles within and across the stream throughout saturated phases (Fig. 6). For each of the curves, equivalent rectangles were constructed to represent the mean observed rate of discharge and the average times at which this could be considered to start and end. Essentially, the product of the indicated duration of flow and the mean rate of discharge gave the average number of vehicles leaving the lane during saturated phases. The time difference between the equivalent duration of saturation flow, indicated by the rectangles, and the total time available for the flow during each phase represented the lost time, the total time available for flow during each phase being defined for the purposes of this study as 'red-amber plus green'.

Saturation Flow

From the analysis of time intervals between vehicles during saturation flow, the value of this flow can be equated. For this purpose, only a variation with speed has been considered and a mean allowance made for heavy and public service vehicles (i.e. from Equation 3 above).

$$\text{Saturation flow} = \frac{3{,}600}{(2.75 - 0.042a)\left(\frac{100+0.6H}{100}\right)} \text{ vehs. per hr.}$$

. . . Equation 6.

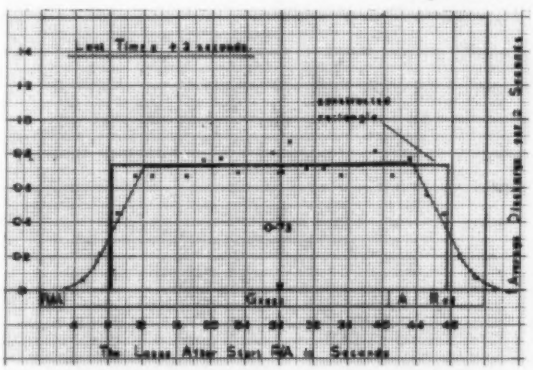

Fig. 6. Typical saturation flow curve for saturated phases.

TABLE III

Comparison between estimated and observed rates for saturation flow.

Code No. of approach road	*Saturation flow in vehicles per two seconds*		
	Estimated	*Observed*	*Difference as per cent of estimated flow**
1	0.92	0.84	−9%
3	0.83	0.84	+1%
4	0.76	0.68	−11%
5	0.77	0.68	−12%
6	0.94	0.86	−9%
7	0.94	0.73	−22%
9	0.82	0.80	−2%
11	0.92	0.92	0%
12	1.07	1.07	0%
13	0.94	0.92	−2%
14	0.95	0.92	−3%
18	0.92	0.85	−8%
19	0.98	0.92	−6%
20	1.04	0.86	−17%
21	1.05	1.04	−1%

*Footnote: It was expected that for 19 cases out of 20 the observed value would lie within ± 20 per cent of the estimated rate of flow.

Such estimates of saturation flow agreed within 20 per cent of the mean observed rates of discharge for 14 of the 15 cases studied. (See Table III). Within this limit, however, there was a marked tendency to over-estimate saturation flow, and this could be explained only partially by the omission of the effects of preceding vehicles and of turning vehicles which together did not account for more than four per cent of this excess in extreme cases. Although no additional allowance was made for vehicles right-turning across the stream, no bias could be attributed to this omission. An explanation of the excess might lie in an observed tendency for saturation flow to increase as phases matured.

Lost Time

Estimates of the time of growth of saturation flow were based on the study of vehicles at the heads of queues. For this purpose, it was assumed that vehicles at the head would travel at 20 feet per second beyond the first 40 feet. In fact, the difference between this estimate and the observed equivalent value was found to be largely attributable to this assumption. Examination of the average time at which saturation flow ceased during saturated phases showed that the flow at the stop line continued for 1.8 seconds after the start of amber, the effect of which was extended by the presence of right-turning vehicles wishing to cross the stream. No influence of the class of vehicle was detected within the latter contribution.

Time at which saturation flow ceases within the intersection = $a.d_o + 1.8 + 0.06R$ seconds after the start of amber

. . . Equation 7.

(90 per cent significant)

From the above considerations lost time was equated and simplified to the form shown at the base of Fig. 7. This constructed analysis indicated that the distances from the stop line to the sides of the cross road, the mean speed of the queue during saturation flow, the composition of the queue including opposing right-turners, and the degree of interference from cross-traffic, all affect the value of lost time. The anticipated contribution of each is readily apparent from the indicator lines in the figure. However, a direct analysis of the observed values of lost time, for 15 of the lanes studied, detected only the influences of speed and opposing right-turning vehicles (Equation 8).

Lost time $= 2.5 + 0.2\,(a - 12.5) - 0.07R$ seconds

. . Equation 8.

(99.9, 80 per cent significant)

TABLE IV

Observed range of lost time

Code No. of approach road	*Observed lost time in seconds*	*Value of last time given by equation 8**
1	3	3
3	3	3
4	1	2
5	2	1
6	3	3
7	2	3
9	3	3
11	3	2
12	3	3
13	2	3
14	−1	3
18	2	3
19	5	3
20	4	3
21	4	3

*Footnote: These values show the extent to which Equation 8 represents the observations.

The values of lost time observed are shown in Table IV. For 14 of the 15 cases, the losses range from one to five seconds. By contrast, a gain of time was experienced in the remaining case and this could only be explained by the high turning movement across the stream which, due to the back-up and speed of the stream, was only able to move at the beginning and end of phases. The apparent lack of influence of inlet and outlet distances on lost time is attributable, for the lanes studied, to the close correlation between these distances, shown in Equation 9, which rendered the effect insignificant.

$d_o = 1.6d_i + 30$ feet . . . Equation 9.

(99 per cent significant)

Optimum Cycle Time

Dr. Webster has shown that the optimum cycle time for signals is related to lost time and saturation flow,[1] according to the approximate equation:

$$\left.\begin{matrix}\text{Optimum} \\ \text{Cycle time}\end{matrix}\right\} = \frac{1.5(\text{Total lost time per cycle of 'n' phases}) + 5}{1 - \sum_{1}^{n} Y_r}$$

. . . Equation 10.

where Y_r is the maximum ratio of flow to saturation flow (q_r/s_r) for the r^{th} phase.

$$\left[2.75 \sum_{1}^{n} q_r + 0.04 \sum_{1}^{n} (q_p - q_r) a_r\right] + 0.67\, Q_p \quad \text{greater than } 3{,}600$$

. . . Equation 11.

where q_r relates to hourly volumes a and the associated speed is flow per hour and q_p the flow on the arm under study.

From the results obtained, it can be shown that where the flow through an intersection is high, lower optimum cycle times can be achieved by increasing the speed of discharge during saturation flow. For the simple case of an intersection carrying only light vehicles with no right turning movements across other streams, this state exists when the following approximate expression holds:

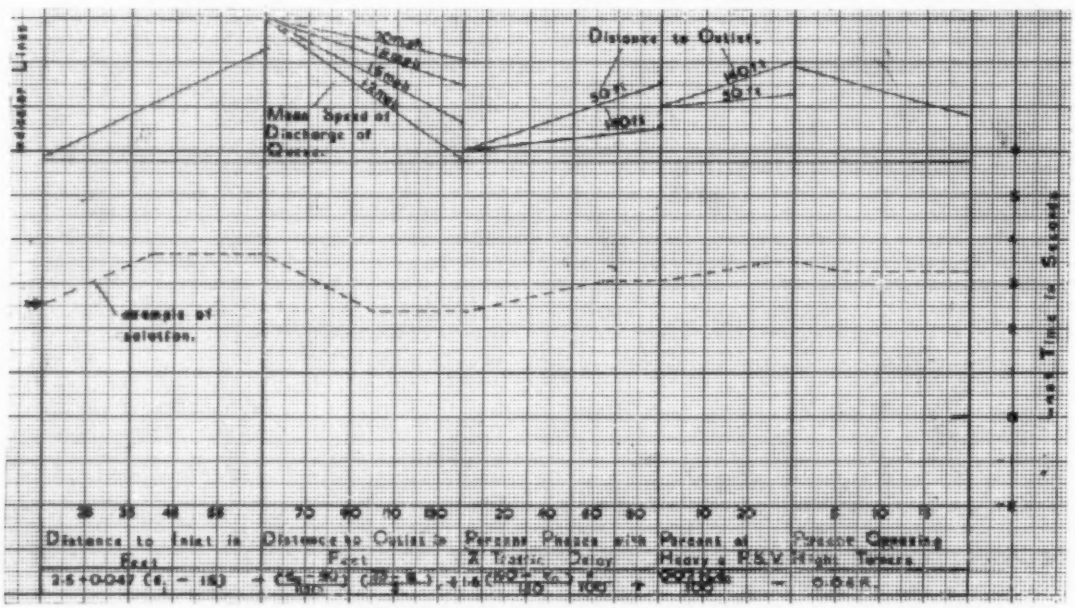
Distance to Outlet.
Mean Speed of Discharge of Queue.
Distance to Inlet in Feet
Distance to Outlet in Feet
Percent Phases with % Traffic Delay
Percent of Heavy & P.S.V. Right Turners
Percent Opposing
2.5+0.04? (s_i − 15) − (s_r − 30) (?? − ??) + 1.8 (60 + ??) − 0.07R

Fig. 7. Constructed equation for lost time.

$$\text{Saturation flow} = \frac{3{,}600}{(2.75 - 0.042a)\left(\frac{100 \% 0.6H}{100}\right)} \text{ vehs. per hr.}$$

. . . Equation 6.

Below this level the cycle time increases with speed. That the reduction in cycle time, resulting from an increase in speed for high flows, leads to an associated reduction in the average delay to vehicles is confirmed by an examination of the delay formula from which the optimum cycle time was derived.

Summary

The researches relate to light-controlled intersections at which traffic flow emerges from approach roads in single-line formation except for vehicles wishing to turn right, these being accommodated on the crown of the road without interfering with other traffic. These right-turners have been considered relative to the stream across which they turn. The range of conditions for which the results were obtained is shown in Table II. The data has been confined to dry or merely damp conditions.

(1) Two and a half seconds after the start of red-amber the first vehicle in a queue begins to move and subsequent vehicles start at intervals of one and a half seconds.

(2) The time taken by the first vehicle to cross the intersection is a function of the distance of the stop line from near-side of the cross-road and of the degree of saturation during the preceding phase.

(3) Within a queue, vehicles leaving an intersection attain a steady rate of discharge or saturation flow, which is inversely related to the speed of the queue and for which heavy and public service vehicles respectively occupy 50 to 70 per cent more space than light vehicles. This steady rate is achieved by light vehicles beyond the second position in queues and by heavy and public service vehicles beyond the fourth position. Light vehicles turning freely in isolation through acute angles have no significant effect on the rate of discharge, whilst heavy and public service vehicles have a 25 per cent greater effect than if they travel straight through. However, for obtuse turns the effect is more serious.

(4) At the end of green periods in which queues of vehicles do not completely clear, flow continues at the stop line for a further 1.8 seconds, on average, after the start of amber. Within the intersection this continuation of flow is further extended by opposing right-turners. The effect of this continued occupation upon the flow of vehicles in the following phase is apparently governed by the location of the stop lines for that traffic and the width of the road which that flow crosses.

(5) From the analysis of the behaviour of vehicles it was expected that the siting of the stop line, the width of the cross-road, the composition and speed of the stream, and the percentage of phases subjected to delay from the continued cross-flow of traffic at the start of the phase, would influence the lost time for a given stream. It was found, however, that only the influence of speed and of opposing right-turning vehicles could be detected, lower values of lost time being associated with low speeds and high percentages of right-turners.

(6) As flows increase it becomes important to ensure that streams can travel at higher speeds and so minimize the average delay to vehicles.

Conclusions

The findings of these researches are intended primarily to increase the understanding of the behaviour of traffic at light-controlled intersections. However, certain indications have emerged which, whilst still requiring further study, may be of immediate interest to the practising engineer. In particular, the effect of speed and of the location of the stop line should be noted.

The results obtained suggest that, for the purposes of calculating the optimum cycle time, approximate values of saturation flows and lost time may be estimated from measurements of the mean speed of discharge during saturation flow,* by the use of the following expressions:

Lost Time $= 0.2a - 0.07R$ seconds
(for concurrent ambers) . . . Equation 8.

At intersections to which the above relationships apply, vehicles within high flows should be encouraged to achieve speeds of at least 20 miles per hour during saturation flow. Aids to this might include the delineation of waiting lanes for right-turning vehicles, pedestrian guard-rails and speed-advice signs. Further indications are that in order to minimize lost time the stop line should be placed as close to the cross-road as possible and, for this purpose, a distance of 16 feet from the near-side of the cross-road would seem compatible with the fluctuations in the stopping practice of drivers and within the needs of pedestrians.

*Within the studies made, the speed was measured by timing vehicles over 44 feet at the exits to intersections, the observers' readings having been calibrated previously against enoscope measurements over 176 feet.

ACKNOWLEDGMENTS

The author wishes to express his appreciation of the guidance and encouragement given by: Trustees of the Rees Jeffreys Road Fund, Dr. W. Fisher Cassie, Professor of Civil Engineering, University of Durham, Dr. T. E. H. Williams, Rees Jeffreys Reader in Highway and Traffic Engineering, University of Durham, Professor J. H. Jones, formerly of the University of California, Dr. F. V. Webster of the Road Research Laboratory.

REFERENCE

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OVERSEAS ROAD RESEARCH

The Committee on Colonial Road Research, which was set up in 1955 to advise the Secretary of State for the Colonies on matters of road research for the benefit of the colonies, is to be replaced by a new body with wider terms of reference to meet the changed circumstances of the present day. It will be constituted as the 'Committee on Overseas Road Research' of the Road Research Board with Sir William Glanville, C.B., C.B.E., D.SC., M.I.C.E., F.R.S., Director of Road Research, D.S.I.R., as its Chairman. The new committee will advise the Board on matters of research concerned with problems of roads and road transport abroad. His advice will also be available to the Secretary of State for the Colonies.

Fig. 1. A night accident to a parked car. The car was struck in the rear by a heavy lorry and pushed against a lamp column.

PARKED VEHICLES on RURAL ROADS

by G. GRIME, O.B.E., M.Sc.
Road Research Laboratory

In this article the author discusses some recent estimates of the part played by parked vehicles in accidents on rural roads and shows how large this may be on certain roads.

THE parked vehicle is one of the most important factors in accidents on rural roads in Great Britain. This was shown by Coburn in 1954 in the course of an investigation by the Road Research Laboratory into accidents in rural Buckinghamshire for the period 1946-50[1]. He found that parked vehicles were involved in 14 per cent of all personal-injury accidents on a sample of Class I and Class II roads carrying about 70 per cent of the total vehicle mileage in the county. Some further information on accidents of this kind has recently been examined and the results appeared to be of sufficient interest to form the subject of this paper.

In late 1955, an investigation was started of accidents involving personal-injury or damage and occurring within a distance of about eight miles from the Road Research Laboratory at Langley. Up to May 1959, about 400 accidents had been examined in detail, almost all at the sites of the accidents and within a short time of their occurrence. Very few night accidents were included, since the investigations were almost all made in working hours. Of the 400 accidents, 190 occurred in non-built-up areas, and of these 26 (13 per cent) involved a parked vehicle. Twenty of the parked vehicles were commercial vehicles, four were cars, one was a motorcycle combination, and one was of unknown class. (In this investigation parked vehicles are all those vehicles which are stationary on the carriageway, except ones which have stopped because of the traffic conditions or because they are executing some manoeuvre.)

In 12 instances the parked vehicle restricted the width of road available so that the moving vehicle hit either the parked vehicle or another moving vehicle, but in the remaining 14 instances in which the parked vehicle was hit in rear, there was no third vehicle. In nine of these 14 two-vehicle accidents there was no apparent reason for the accident; eight of the nine occurred by day and on straight roads when the obstructing vehicles must have been easily visible. This emphasizes the fact that merely to ensure that an obstruction is visible to an approaching motorist is not enough to prevent accidents of this kind.

The three night accidents involving parked vehicles were reported to the Laboratory because of their severity, seven people being killed in the three accidents. In one accident an unlighted lorry carrying tree trunks, and in a second a lorry with rear lights, was struck from the rear by a car; in the third

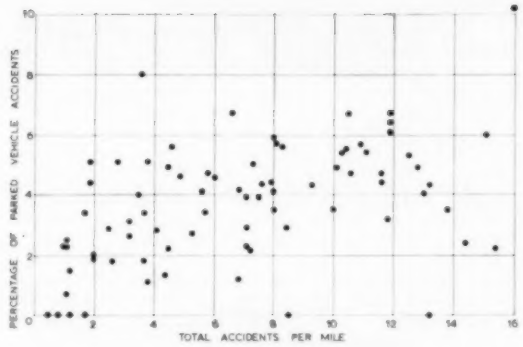

Fig. 2. Percentages of parked vehicle accidents on trunk and class I roads 1954/58.

accident a parked car was hit by a lorry and pushed into a lamp column. Fig. 1 shows the result of the third accident.

Comparison with Police Estimates

The percentages of parked vehicles found in this on-the-spot accident investigation, and in other accident investigations by the Laboratory, are about three times as great as those deduced from figures obtained by the police for the country as a whole. For example, Garwood[2] in September 1959 showed that, according to police reports supplied on Ministry of Transport forms for 1958, parked vehicles form about three per cent of the total number of vehicles involved in serious or fatal accidents in areas without a speed limit. The percentage of all accidents in which a parked vehicle is involved is slightly greater than this, in this case 4.5 per cent.

Investigations, described below, suggest two explanations of the difference between the police figures and those obtained by the Laboratory:

(1) That the police interpretation of the term 'parked vehicle' is different from that just given.
(2) That the particular roads considered in investigations by the Laboratory have exceptionally high percentages of parked-vehicle accidents.

In an attempt to explain this difference, the detailed police records of all personal-injury accidents on roads A5, A40 and A413 in Buckinghamshire in 1956 and 1958 were examined in order to obtain a sample of accidents in which parked vehicles were involved. This examination should be less subject to bias than that provided by the on-the-spot accident investigation by the Laboratory. Out of a total of 621 accidents which occurred on the parts of these roads which had no speed limit, 101, that is 16 per cent, were judged to have involved parked vehicles. It is of interest to note that in 16 out of 58 parked-vehicle accidents involving only two vehicles the road was straight, and there was no apparent reason for the stationary vehicle to be hit. If only serious and fatal accidents are considered, 38 out of 247, that is 15 per cent, involved parked vehicles.

An attempt was then made to find how these 38 accidents were classified on the appropriate Hollerith cards compiled from the police reports given on the Ministry of Transport forms (which, however, relate only to serious and fatal injuries). It was found that 21 were classed as 'parked', 10 as 'stationary, temporarily held up', and seven did not appear in these two classes and were not readily traceable. It is clear, therefore, that there is a real difference between the police figures and those of the Laboratory, and that this is due to a difference in the interpretation of the term 'parked vehicle'. For the sample of accidents considered, the percentage of parked vehicles found by the Laboratory, 15 per cent, was nearly twice as great as that found by the police, which was eight per cent.

However, even the lower figure of eight per cent for these three A roads in Bucks is about twice the average found by Garwood for rural roads in general, and, in an attempt to explain this, the police figures for the percentages of parked-vehicle accidents for Trunk and Class I roads in most of the separate counties of England, Wales and Scotland were examined for the years 1954-58. They are plotted in Fig. 2, against the number of accidents per mile on these roads in the same years, used as a measure of traffic.*

There is a general tendency for the percentage of parked-vehicle accidents to rise with the total number of accidents per mile, and it is noteworthy that Buckinghamshire, with a percentage of seven, has one of the highest rates.

On the average, therefore, it appears that police figures under-estimate the percentage of accidents in which a parked vehicle is involved by a factor which is not accurately known, but is probably about two. Furthermore, in some areas such as Buckinghamshire the percentage may be double the average for the whole country.

On certain lengths of road, perhaps possessing unusual features, even higher percentages have been found; for example, out of 265 accidents on the Perth-Stirling road in the years 1951-6, 52, that is 20 per cent, involved parked vehicles; and on a certain length of A40 between September 1955 and December 1956, 20 accidents out of a total of 54, that is 37 per cent, involved parked vehicles.

Parking off the Carriageway

In the United States of America, the problem of parked vehicles has been tackled by prohibiting stopping on the carriageway of rural roads; that is the law in 45 States, and it appears to be accepted by motorists, since parked cars are very rarely seen on important rural roads in America.

It is sometimes argued that a similar prohibition, applied to A roads, on which 80 per cent of these accidents occur, would be unworkable in Great Britain.

(*a*) Because the motoring public would never stand for such a prohibition.
(*b*) Because vehicles cannot stop or park except on the road because of high kerbs and verges.
(*c*) Because verges will be damaged if vehicles leave the road.
(*d*) Because verges do not exist on some A roads in non-built-up areas.

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*More exactly, for each county,

$$\frac{\text{accidents on Trunk and Class I roads without a speed limit}}{\text{mileage of rural Trunk and Class I roads}}$$

The first two objections, however, do not carry much weight since it has been found that a large proportion of motorists already park off the carriageway. Counts of parked vehicles on the road between Maidenhead and Beckhampton were made in the course of eight journeys during the period October 1957 to May 1958, and, out of 522 stationary vehicles, 318, 61 per cent, were parked off the road. The results for vehicles of different classes are given in Table I, which also shows the use made of lay-bys. It appears, then, that the majority of motorists already park off the carriageway. Kerbs are no great obstacle, since many of the properly parked vehicles had been driven over kerbs in order to leave the road.

As regards private cars, no great difficulty would be likely to arise if they were prevented from stopping on the highway. Since a large proportion already park off the road and not in lay-bys, the extra damage to verges might be expected to be slight, and on roads where no verges exist their occupants would be subject only to the slight inconvenience of travelling some distance to look for a suitable spot to pull off the road.

Commercial vehicles present greater difficulties since many of those parked on the road are probably delivering goods. Further, to provide parking space off the road for heavy goods vehicles, which might sink into ordinary verges, extra lay-bys might be required. It is very important, however, to take all necessary steps of this kind, since Garwood[2] shows (Table I) that heavy goods vehicles are involved as parked vehicles in about one-fifth of all accidents of this type, and in a higher proportion, about one-third, of those that occur at night.

TABLE I

Numbers of parked vehicles on A4 between Maidenhead and Beckhampton—October 1957 to May 1958

Type of vehicle	*Parked on road*	*Parked off road*		*Total parked vehicles*
		In lay-bys	*Not in lay-bys*	
Cars	60 (35%)	39 (23%)	73 (42%)	172
Lorries	69 (36%)	106 (55%)	16 (8%)	191
Vans	69 (52%)	18 (13%)	47 (35%)	134
Motor-cycles	6 (24%)	8 (32%)	11 (44%)	25

Total mileage = 400; on the average one vehicle was parked on every two miles of road.

ACKNOWLEDGMENTS

The co-operation of the Buckinghamshire Police in making records available and in discussion is gratefully acknowledged.

The article is published by permission of the Director of Road Research.

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MAY Issue

Special Anniversary Number

Importance of Traffic Engineering
John Hay, M.P.
Parliamentary Secretary to the Ministry of Transport

A Question of Priorities
Sir William Holford
President of the R.I.B.A.

Need for Urban Motorways
Wilfrid Andrews
Chairman of the R.A.C. and Roads Campaign Council.

Revised Manual of Traffic Control Devices
Burton W. Marsh and William L. Carson
American Automobile Association

Planning Munich's Transport
Professor Dr.-Ing. habil. K. Leibbrand

Street Lighting: 12 Months Developments
Granville Berry, M.Inst.C.E., M.Inst.Mun.E.
City Engineer and Surveyor, Coventry

Profile of Dr. J. Kolbuszewski
Professor of Highway and Traffic Engineering
University of Birmingham

Parking Section: Parking Meter Scheme, Auckland, New Zealand

Report from U.S.S.R.

MOSCOW'S URBAN MOTORWAYS

by Professor A. E. Stramentov

Corresponding member of the Academy of Building and Architecture of the U.S.S.R.

IN the U.S.S.R., where the population of urban centres already totals 100 million inhabitants, the problems of the organization of urban traffic and its safety are solved not only by technical measures of a general nature, such as green zones, pedestrian subways, two level intersections and controlled access motorways, but also by the individual examination of each city's main transport problems set against the background of town planning. The general plans for both the rebuilding of old towns and the construction of new ones, always include two zones: those set aside for buildings and those intended for communications.

The planning of urban transport is studied in the U.S.S.R. from the following points of view:

(*a*) Assessment of the size of the future population, classed according to the factors of urban life determining the nature of the occupations of the inhabitants: their work in industry, institutions, and other employment.

(*b*) Respective location of the industrial and residential zones, allowing for their development or future rebuilding up to 1980, as well as the location of the green belts dividing the residential from the industrial areas.

(*c*) Means of accommodating the population in groups of four to five storey blocks, intended for 15,000 to 25,000 inhabitants.

(*d*) The role played by passenger and goods transport in the life of the town, preferences for different forms of transport, and the volume of traffic and its organization.

These estimates make it possible to determine the annual number of journeys made by all forms of transport by each inhabitant. In large towns it reaches 900, in medium-sized towns 650 and from 300 to 450 in small towns. At present in the U.S.S.R., owing to the reduction in the number of working days and the length of the working day, by 1980 a decrease is anticipated in the number of journeys from places of residence to places of work, an

Fig. 1. Yaroslavskoye Chaussee, a typical Moscow street.

increase in the journeys of the population to places of relaxation or recreation, and a rise of about 20 to 30 per cent in social journeys.

For all computations of the future activity of urban transport, the calculation of the 'index of compactness' is of the greatest importance, for it allows for the average distance separating the residential quarters from the town centre. This embodies not only the distances separating the different districts of the town from its centre, but also the density of population, the frequency of the journeys and the density of goods transport. A town may thus be divided into zones according to the distances in kilometres from the centre. The mean distance is determined according to the number of inhabitants in each zone and the respective spacing of the places of residence according to the formula:

$$L = \frac{\Sigma h \times l}{H}$$

where

h = population of each zone,
l = mean distance from the zone of the town centre in kilometres,
H = Σh = population of the whole town.

It is obvious that two towns having the same population may have different mean indexes, since the latter depend on the distribution of the inhabitants and the planning of the urban area. The maximum distance depends on the population of the towns. The time of transport should not exceed 30 minutes by any means of transport in average-size towns.

In the course of the enquiry into the technology of road traffic and transport structure on the main highways, the plan of the town is rectified and measures are applied which make it possible to reduce to reasonable limits the time spent by the citizen in travelling. Several ancient towns in the U.S.S.R.—Moscow, Kazan and others—as well as those of western Europe, such as Paris, are planned in accordance with the radial and ring road system. Everyone is familiar with the increasing difficulties of traffic with radial streets running out from town centres.

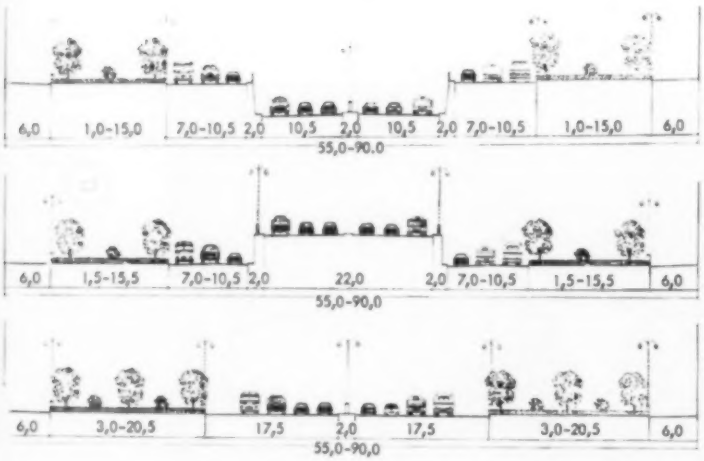


Fig. 3. Cross sections of The Moscow Peripheral Motorway. Top: The motorway with two carriageways of three traffic lanes each: each runs in tunnel below a radial motorway. The lateral highways, placed side by side, with three traffic lanes, constitute connecting branches. At the sides of the section are the service roads for the blocks along the highway. In the centre, the same motorway crosses another at a higher level. At the bottom, a section of standard roadway. (The figures are in metres for the three sections.)

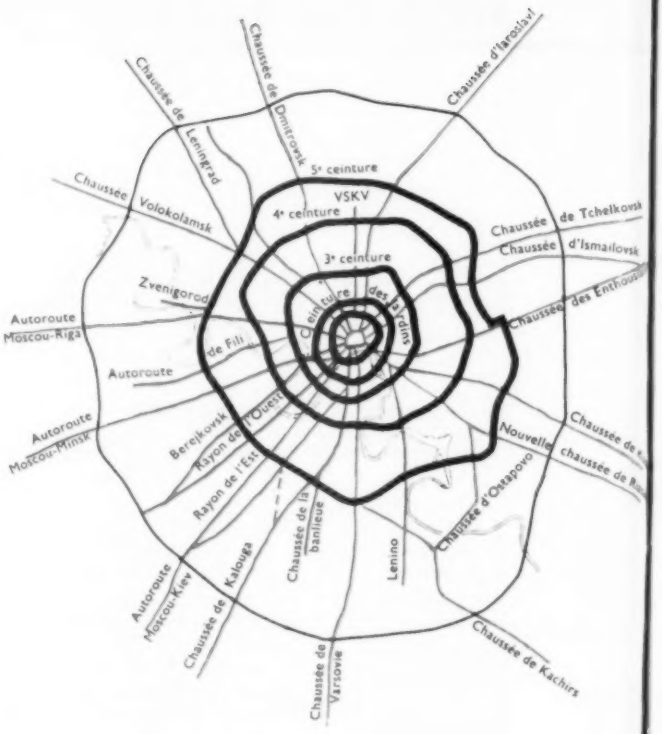


Fig. 2. Diagram of Moscow. In the centre, the heart of the capital. In the form of concentric circumferences, the planned motorways. The outermost is the peripheral belt, referred to primarily in the text, and construction of which has started. Near the centre, the Garden Belt bounding the central area of the city. Along the urban motorways or main arteries, four basic speeds are provided for: 120, 80, 60 *and less than* 60 *km. per hour. The red lines indicate the radials.*

Plan for Moscow

In Moscow, considerable transport difficulties have already arisen, especially in the central districts, in spite of the application of a modern system for controlling traffic on the main city streets of what is termed the 'Garden Belt' (Fig. 2.) In order that the part played by the main arteries may conform to the needs of modern traffic, the development of the radial-circular system of the city is planned by varying the speeds to meet the needs of the main roads.

On the outer periphery of the city (Moscow covers 875 sq. km.), a circular motorway, 109 km. long, is under construction. This circular road is being built

(*Concluded on page* 731)

Signal Control

CHAPEL ASH

WOLVERHAMPTON

THE multiple intersection Chapel Ash, Tettenhall Road, Bath Road and Merridale Road, Wolverhampton is used by traffic travelling between the industrial areas on the west side of Birmingham and North Wales and the north-west coast. It is consequently a very busy junction.

The question of improving traffic movement had been under consideration for some years but no progress could be made until the building housing a public convenience and an electricity sub-station could be moved. This building was a serious obstruction to the orderly movement of traffic. A suitable alternative site was found and it was decided to install vehicle actuated signals to control traffic from the five main approaches. The scheme was developed by the Ministry of Transport in collaboration with Wolverhampton Borough Council and S.G.E. Signals Ltd.

A circular island in the mouth of Chapel Ash was removed and replaced by a long triangular island and the kerb in Merridale Road was set back to allow the long central dividing islands to be constructed. Signals and detectors were then installed as shown in Fig. 2.

The controlled area is basically treated as two junctions. The major junction, identified as junction X, is that of Tettenhall Road, Bath Road and Chapel Ash. The minor junction, identified as junction Y, is that of Compton Road and Merridale Road. The signals at this minor junction also control vehicles which veer left from Chapel Ash and wish to pass into Compton Road. No control is provided for traffic from Lord Street as such traffic is required to turn left when leaving Lord Street.

A vehicle actuated controller is installed at each junction. That at junction X is capable of allowing four traffic movements whilst that at junction Y is a simpler controller giving two traffic movements.

Fig. 1. The multiple intersection Chapel Ash, Tettenhall Road, Bath Road, Merridale Road, Wolverhampton where the vehicle guided road signal installation described in this article is in operation.

The amount of eastbound traffic out of Compton Road and Merridale Road during the daytime is sufficient to require co-ordination of the two signal controllers and provision has also to be made at the same time for the heavy right-hand turn from these roads into Chapel Ash. How these requirements are met is described below.

As already mentioned, the controller at junction X is capable of allowing four traffic movements shown as stages 1-4 in the method of control shown in Fig. 2. The main two movements are Stages 2 and 4. The other two Stages (1 and 3) are introduced to allow for the right-hand turn into Chapel Ash.

Stage 1 is given if a vehicle has passed over detector AD and is of short duration because its purpose is to allow straight through traffic from Bath Road to establish itself against vehicles waiting to turn right into Chapel Ash. These vehicles draw forward and wait during Stage 2 which is demanded by detector AB and extended by detector AD. They are able to make an unobstructed turn during Stage 3 which is extended by detector AB. (The AB detector in this description means the two detector layouts shown as AB1 and AB2 on the drawing. They both perform the same function). Stage 4 gives right of way to traffic in Tettenhall Road and Chapel Ash, being demanded and extended by detectors C1 and C2. It will be seen that vehicles turning left from Chapel Ash pass to the south of the triangular island and can proceed during both Stages 3 and 4.

The controller at junction Y operates as shown in the Method of Control, a green signal being normally given to Compton Road traffic and that from Chapel Ash which is passing into Compton Road (Stage 1). The operation of the controller is co-ordinated with that at junction X so that a change is only made to Stage 2 when the controller at junction X changes to Stage 3, provided a demand has been registered on detector B. The AB signals at junction X are thus at green, ready to pass traffic from Merridale Road into junction X, that from Compton Road having either moved through during Stage 2 or during the first part of Stage 3 at junction X.

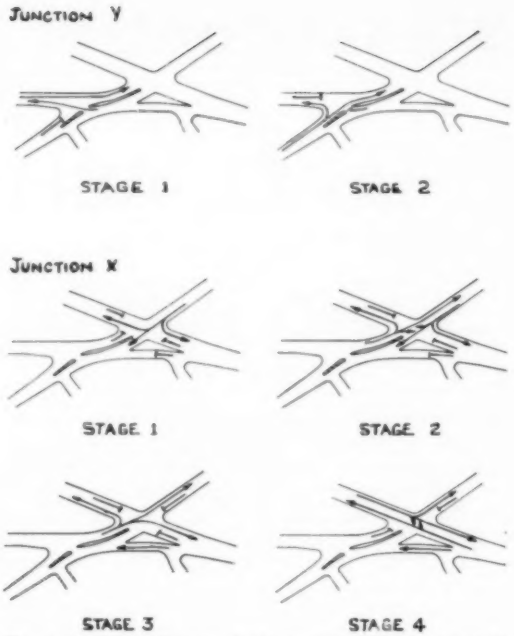


Fig. 3. A series of diagrams to illustrate the method of control employed. The different stages are given to show the various traffic moves.

Stage 2 at junction Y is extended by detector B but it cannot be extended beyond the end of Stage 3 at junction X. Stage 2 at Y can terminate before Stage 3 at junction X and this is illustrated in Fig. 3, where Compton Road has just received right-of-way (Stage 1 at junction Y). Merridale Road traffic, therefore, cannot block back and obstruct vehicles coming out of Compton Road.

The co-ordinated operation just described is essential when traffic is busy but not during slacker traffic conditions. There is also of course a considerable reduction in the amount of traffic turning

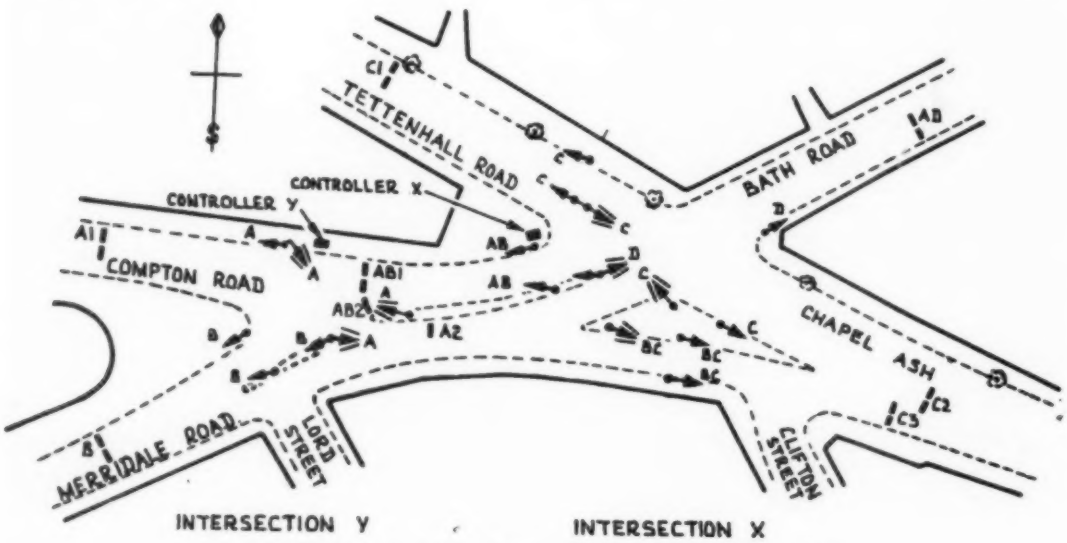


Fig. 2. Plan of the street layout showing the signals and detectors in position.

right into Chapel Ash when the total volume of traffic decreases. Means are, therefore, provided for switching the controllers to independent operation and, at the same time, omitting Stages 1 and 3 of the controller at junction X. This, incidentally, necessitates a change in the functions of detectors AB and AD which now demand and extend Stage 2 of controller at junction X.

It has been found that traffic requirements are best met by co-ordinating the operation of the controllers between the hours of 7 a.m.-7 p.m. and switching them to operate as independent units outside these hours. This is achieved by means of a time switch fitted in the controller at junction X. A manually operated switch is also provided so that the controllers can be set to co-ordinated or independent operation irrespective of the setting of the time switch.

These Autoflex installations were brought into use on October 13, 1960 and have since proved most satisfactory in handling the traffic at these very busy intersections.

Acknowledgment

At the request of Traffic Engineering & Control *this article was contributed by S.G.E. Signals Ltd., to whom acknowledgment is made.*

Fig. 4. Chapel Ash junction showing traffic flow at Stage 1 at junction X with traffic from junction X awaiting release.

Moscow

(*Concluded from page* 728)

in accordance with the characteristics of motorways providing uninterrupted traffic. All the intersections will be at different levels, by means of flyovers or underpasses. The motorways will have dual carriageways, each of three lanes 10.5 m. wide, separated by a planted central reserve. On either side of the motorways it is proposed to plant trees and shrubs to protect the residential area from noise and dust. The design speed of this ring road is 120 km./h., which should enable half the circumference of the peripheral highway to be traversed in 30 minutes. All through traffic will avoid the city by this circular road, which will likewise provide communication between the suburban areas. Since it runs beside parks and woods, it will also be used for journeys to places of recreation.

Inside the city, at the same time as the rebuilding of the Garden Belt, it is proposed to construct three new circular motorways. On a fourth, the Parks Belt, the plan provides for traffic to be distributed at different levels to all the radial motorways. Urban roads are also being planned, parallel to the main radials, which will give access to the fourth belt and which will join it at different levels. On these arteries, and on the fourth belt, therefore, traffic flow will be uninterrupted. Their design speed is to be 80 km./h. Thus all communications between the different quarters of the town outside the fourth belt, where 70 per cent of the population will be accommodated, will be served by this belt, without encumbering the central zones. The inhabitants of that region of the city situated within the fourth belt will be served by transport using the radial arteries and the Garden Belt with, between them, points for separating the traffic at different levels. Their proposed speed is 60 km./h. The third and also a fifth belt will be used for local traffic.

The planning of the urban road system is thus designed with the idea of counteracting the centripetal movement of transport by means of centrifugal movement from the centre, using the expedient of successive increases in the speed of traffic from the centre to the periphery. Moreover, it will be possible to ensure the flow of larger volumes of traffic on a central system that is relatively less burdened. Better efficiency of the road system will thus be obtained, which will guarantee the more convenient location of the residential zones, which will be situated between the urban motorways, and, as far as possible, away from through traffic.

Construction of the motorway is proceeding apace. In 1959, work started on the building of the flyovers and underpasses at the more important intersections of the Garden Belt. Altogether, 19 intersections have to be built, two of which are already completed. On completion of the work, in 1962, traffic will flow uninterrupted on three lanes in each direction. The motorway will thus appear as shown in Fig. 3.

After the completion of the reconstruction, the Garden Belt, which surrounds the centre of the city, work will be started on building of motorways for the third, fourth and fifth belts. This scheme will also include the demolition of old houses and the erection of new blocks with plantations of trees and the creation of green belts facing the motorways.

Experience in urban traffic planning in U.S.S.R. provides further confirmation that the problems of the organization and safety of urban traffic call for large-scale decisions in regard to town development, and really fruitful collaboration between scientists and technicians.

This article is based on one written by Prof. A. E. Stramentov for 'Etudes Routieres', to whom acknowledgment for permission to publish is made.

By using a small mono-rail car the patrolling authority can be at the scene of any accident or breakdown in the Lincoln Tunnel, New York, with great speed and traffic is flowing quickly again.

DEVELOPMENTS I

This experimental electro-luminescent direction sign is being tried out in the State of California, near Sacramento.

Work in progress on the bridge, near Runnymede part of the new Staines By-Pass scheme.

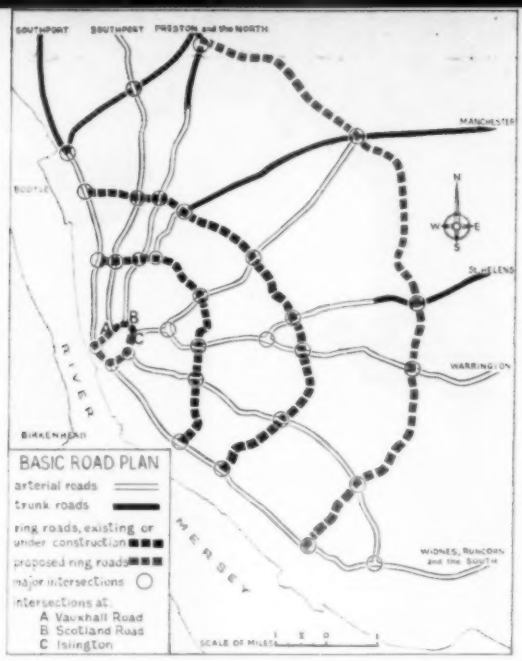
The photograph on the right shows the construction of an elevated road and junction at Mannheim in West Germany. A feature article on planning Munich's transport will be published in the May issue of this journal.

TS ILLUSTRATED

The Hackensack River Bridge on the New Jersey Turnpike. An article on toll facilities in U.S.A. appears on page 712.

An artist's impression of the proposed suspension bridge over the River Severn.

LIVERPOOL'S INNER RING ROAD



FOR many years the construction of an Inner Ring Road in the City of Liverpool had been planned, but it was only after the extensive war damage in the centre of the city, and the urgent need arose to provide for reconstruction, that the City Council was able to consider the first proposals. Plans are now well advanced and a detailed scheme for the section between Moorfields and London Road was recently submitted to the Minister of Transport.

The purpose of the road is to promote the convenient use and the amenity of the central area of the city by deflecting from it all vehicles which have no need to traverse it, whilst affording convenient means of entry to those for which access is essential. It is designed to be a free-flowing highway which will greatly relieve congestion in the centre of the city, partly by providing efficient traffic circulation around its periphery, and partly by giving unimpeded traffic routes to and from the Mersey Tunnel at Kingsway.

The Inner Ring Road is to have dual carriageways throughout, each with widths varying from 33 feet to 20 feet according to the estimated future traffic flows. The median strip is to be four feet wide. Footways will vary in width from 10 feet to 15 feet and guard rails will be extensively used. It will thus not be an urban motorway, but rather a free-flowing highway collecting and distributing traffic in the city centre, which arrives and leaves by the main arterial roads that will connect with the Ministry of Transport's national system of motorways.

The importance of pedestrian traffic has also been considered, and extensive pedestrian segregation is provided at special crossings by subways and overbridges.

Among the many benefits which it is anticipated will accrue from the construction of the road are:

(1) It will serve as an intercepting and distributive road for the northern perimeter of the central area, connecting all arterial roads as they enter the City centre. It will deflect through traffic from the portion of the area it encloses. It will also serve the car parks.
(2) It will provide a direct route to and from Preston and the north for the Mersey Tunnel traffic viâ the underpass in Byrom Street—Scotland Road.
(3) It will completely relieve the traffic congestion, particularly at peak hours, which occurs at the junction of Tithebarn Street, Vauxhall Road, Hatton Garden, and thus facilitate the flow of traffic to and from Crosby, Southport and the north.
(4) It will provide a direct route to and from the east (Manchester, St. Helens, Warrington, etc.) both for Tunnel and City traffic, via the multi-level junction at Islington, William Brown Street, Lime Street. At the same time it will completely remove the traffic congestion which at present occurs at this point.
(5) When the suggested traffic flow arrangements at the entrances to the Tunnel are carried out, they will work in conjunction with this section of the Inner Ring Road to provide completely free flows for traffic entering and leaving the Tunnel.

The route of the Inner Ring Road was adopted after careful investigation of all possible alternatives. Commencing in Tithebarn Street at Moorfields, it passes into Marybone via a roundabout and underpass at Vauxhall Road, then turning eastwards the road crosses Scotland Road, where there will be a multi-level junction consisting of a flyover, roundabout, and underpass. Following the line of Christian Street it crosses Islington by flyover and descends into Lime Street. This is the length which is now proposed to be constructed. From Lime Street the road will eventually proceed to Hanover Street and Canning Place, then along the Strand and Goree, where dual carriageways are already in use, to Chapel Street. From a junction near New Quay the road turns north-eastwards along Chapel Street to complete the Ring at Tithebarn Street.

The main scheme was designed by the City Engineer and Surveyor's Department, but at the end of last year, because of the shortage of engineering assistants, W. S. Atkins and Partners Consulting Engineers, was called in to complete the detailed designs of the section now proposed to be constructed. The estimated cost of this section is between £3 and £4 million, and the Ministry of Transport will give a grant of 75 per cent towards the cost when they have approved the details. Subject to this authorization and grant, it is hoped to start on construction during the summer of 1961.

BRADFORD

REDEVELOPMENT

S. G. WARDLEY,
B.Sc., M.I.C.E., M.I.Mun.E.

Roof car parking in Bradford in partial use during construction.

The City Engineer and Surveyor of Bradford spoke to the Institute of Highway Engineers, Yorkshire and Lincolnshire Branch, on February 2 on 'The Problem of Highways in Relation to the Rebuilding of Towns and City Centres.' Extracts from his paper are given below.

IN an attempt at a definition, it seems the purpose of roads is to take us from place to place in the simplest way, and the problem is the over-taxing of their capacity and the finding of the wherewithall to convert them to the standards of design suitable for their use by the pedestrian and the motor vehicle, with safety to both.

Those of us who remember and took part in the post- World War One construction of new roads and bridges and the improvement of existing roads, realize that even if the traffic conditions of 1960 were not envisaged without this work, our plight during the following twenty-five years of road sterility would have been infinitely worse.

It will be claimed that mistakes were made, but to take two examples at random: the Barnet By-Pass was 100 ft. between fences, and the Tadcaster-York road was designed with cycle tracks, dual carriageways and wide central reserves. The future increase in the volume of traffic had indeed been thought about and catered for to a considerable extent. These are only two examples of a considerable amount of sound road construction, both rural and urban, carried out during the period after the first World War. Moreover, advanced thought in the design of junctions—namely, underpasses and clover leaf junctions—would have been put into practice if funds had continued to be made available on the line of the efforts of these early 1920's. These devices, and the County Surveyor's Society Plan for a system of national motorways, have had to wait two decades to be accepted and put into practice.

The Commonplace Approach

In the main, traffic arises because people wish to go from place to place. However, traffic reacts upon itself. The more convenient and speedier the means of transport, the more people will travel to the place of attraction. The facilities of a village, town or city or port, which in the first place induced the traffic, will by virtue of their attraction expand and induce more traffic by virtue of the convenience which the means of transport has itself created. The inestimable impact of development in the means of transport is shown by the fact that the time taken for King George and Queen Mary to travel to India 50 years' ago (within living memory of some of us) was measured in weeks; today Queen Elizabeth and the Duke of Edinburgh fly to India in a matter of hours.

Are we, therefore, to be denied the convenience of modern transport whatever it may be, because we refuse to face up to the problems it creates?

There would appear to be two 'big bad wolves' today—one is the motor vehicle and the other the town or city which induces it. The appalling loss of life and personal injury caused by traffic on the road is such as to cause one to regard the motor vehicle in this light; to regard it as a lethal weapon which, like railway traffic, should be segregated from the rest of the public.

My own view, shared I believe by the vast majority of people, is that good driving and anticipation plus patience and courtesy would prevent the vast majority of accidents. If this cannot come about, then segregation is the only answer.

Segregation of Traffic

Between the towns the motorway takes care of the pedestrians and the cyclist and to a large extent the motor vehicle, but it is still not as safe as the railway. Segregation in urban areas will mean a complete system of roads for wheeled vehicles and similar segregation of ways for pedestrians, probably at different levels. It is, of course, not beyond the wit of civil engineers to devise such a town or city. In fact, one

might say such towns would be a civil engineer's paradise. Carried to its logical conclusion, however, segregation deprives the motor vehicle of its virtue —the convenience of taking the traveller from door to door. If we are to plan our towns with segregation of traffic as the criterion, then the obvious question arises, why not revert to rail travel both above and below ground?

No town provides the same problem or the same solution. Common sense indicates that some compromise will evolve out of our present difficulties and that it is necessary to keep ever before us a sense of proportion, for the urban problem ranges from the village to the metropolis.

As an extreme illustration of this compromise, I considered that London can best ease its problem of travel congestion by duplicating its tube railways. The answer I shall get is that the cost is prohibitive. But I would suggest nothing like the cost of effecting the same degree of relief at ground level. This, of course, must sound like plain heresy to a meeting of the Institution of Highway Engineers!

The problem of traffic is capable of solution if viewed in a comprehensive way. The solution, if capable of realization, must contain several elements. We must first and foremost strive for new and improved roads with the most up-to-date devices and designs to meet the present day flow of traffic and a reasonable allowance for future increases. But it must be remembered that perfection in this sense is impracticable. There will be certain conditions and occasions when the flow of traffic will be reduced below what should be its normal performance. For instance, people love to visit a town in vast numbers on special occasions. London's Oxford Street and Regent Street might be widened in accordance with the best observations and estimate of traffic engineering, but visitors to the Christmas illuminations would still cause the police and traffic wardens to scratch their heads. If, however, all the pedestrians in towns were segregated to first-floor level and all the traffic at ground level, the streets would present such an inconvenient and unattractive appearance that nobody would bother to visit them.

Clearly, traffic must in addition be disciplined both in its behaviour in movement and in its habits of parking. Off-street and restricted kerbside parking must be another element of the comprehensive outlook.

Bradford Redevelopment

In approaching the task of preparing a plan for rebuilding the City Centre and the Development Plan for the whole of Bradford, traffic and the causes which induce it has had the most careful study. The solutions to the traffic problems which have been proposed have been approached along the lines propounded in this Paper.

Problem to be Solved

The problems of the city centre are the relief of traffic congestion, the need for an adequate route through the centre, adequate off-street car parks and a bus station, the extension of the shopping area, new office accommodation and additional civic buildings, provision for a new theatre and the growth of entertainment and an area for the development of higher education.

Each town faced with the rebuilding of its city centre will have a plan peculiar to itself. The topography of Bradford, for example, is such as to exert a great influence on any attempt at replanning.

City's Growth during Industrial Revolution

Bradford grew up in the folds of the Pennines and originated on the floor of a valley where several valleys converged. Since the location of its roads was largely dictated by its steep contours, this valley formed the focal point of road communication. At this point, too, the township has its outlet to the west through the Aire Gap. In 1800 the population was 13,000 and today Bradford is a city of nearly 300,000 people.

What was originally Bradford is now the centre or hub of a city covering an area of some 40 square miles. Its growth has been the result of the industrial revolution of the 19th century and, although drastic changes took place during this period, the road pattern is inadequate and unsuitable for present day conditions. There are three points of severe traffic congestion and no adequate way through the immediate centre.

Traffic Census

An origin and destination traffic census showed that at least 50 per cent of the traffic was passing through the centre because there is no other alternative route. Moreover, it was deduced from this survey that this through traffic could be assigned to a ring road approximately one mile in diameter which would circumscribe the centre of the City. Furthermore, it was proposed to design and construct a road system to cater for traffic needing to go into the centre but, at the same time, creating a shopping precinct free from unnecessary through traffic, but nevertheless conveniently encircling and serving the shopping area by public service vehicle routes.

Effect of Topography

Bradford has a relatively small area of level land in the centre surrounded by steeply rising hillsides. Its staple textile industry established itself on this flat area as it was the focal point of, first, its road communications and, later, the two railway termini. These rail termini are at different levels as the result of one route coming into the centre the easy way, up the valley, and the other the hard way, over the hills. They have the effect of hemming in the City Centre and making expansion difficult.

As the result of industry growing up in the immediate centre, shopping has developed in a fairly compact way on the northern hillside. But in recent times a change has been taking place showing a tendency for shopping to extend down on to the level area. This part of the City Centre offered great physical advantages as level sites with frontages and depths suitable for large stores, combined with smaller shop units could be provided. To do this meant the closing of streets and drastically recasting the pattern of this part of the City Centre.

The plan for the City which I was commissioned to prepare, and which has been approved by the City Council, brings this about. As the new road pattern comes into being, together with the development of the extended shopping area—a shopping precinct will evolve, into which only vehicular and pedestrian traffic concerned with shopping need go. The planning of this shopping area will ultimately permit certain streets to be converted entirely into pedestrian ways only. Shopping must be convenient to be attractive and pedestrian shopping precincts in a large town can only form part of the main shopping area and they must be geographically right in relation to the area as a whole.

Off-Street Car Parks

The provision of adequate off-street car parks and discipline in street parking is an essential factor in the attempt to redevelop town centres. A survey of parked cars in Bradford showed that permanent off-street car parking for at least 2,000 cars within the central area circumscribed by the proposed City ring road was required. The Council also propose to make orders prohibiting parking in certain streets and to regulate parking in others. There is every reason to believe that a practical solution to the parking problem can be achieved.

Progress in Replanning

I have endeavoured to set out the problems to be solved in rebuilding the centre with the emphasis on the traffic requirements and briefly to outline the approach to its solution. If there is value in so doing, it is because the plan for the City Centre is actually being realized. Large new building projects for new shops and stores, claimed by the traders to be, in one instance, at least the most up-to-date of their kind in the world, together with modern office accommodation, have been completed and are under construction. This work is at least five years ahead of the time laid down in the building agreements. The first section of a new central road, including the redesigning of Forster Square, is proceeding. The Council has also resolved to build a central library and new law courts.

Substantial progress is also being made in the provision of permanent off-street parks and a roof car park for some 200 cars is included in one large shopping and office development. This is partly in operation, and people can come into the City's new shopping centre, park their car and enter the shops at first-floor level. An agreement has also been entered into with a private company to build a multi-storey car park for 700 cars with a petrol station and showrooms at ground floor level. The site fronts to the 95 ft. wide new road through the City Centre, part of which road forms the southern boundary of the shopping precinct. Furthermore, the Council have approved a scheme designed by my department for the development of the retail market which includes a three-level ramp car park for 360 cars, and a market stall area covered by a 230 ft. single span arched roof at a cost of £270,000.

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For the Institution of Civil Engineers Traffic Engineering Study Group, Mr. A. G. Duff, Senior Engineer, Ministry of Transport, prepared a short bibliography of traffic engineering, incorporating the one originally compiled by the library of the Road Research Laboratory, Department of Scientific and Industrial Research, which has now made further revisions for its publication in Traffic Engineering and Control. This is being printed in sections, the first of which was published last month while the second appears below.

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6. SKIDDING RESISTANCE

By B. D. RICHARDSON

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THE skidding resistance of a vehicle is provided by the frictional force developed between the tyres and the road surface. For a level road, it is obvious that any acceleration (whether positive or negative) is dependent on this frictional force and it can be shown that:

$$a = ug$$

where a = acceleration (+ve or −ve)
u = effective coefficient of friction between tyres and road surface.
and g = acceleration due to gravity.

Accordingly, in the study of any manoeuvre involving acceleration, and particularly in those situations where acceleration rates are likely to be severe, it is necessary to be able to measure the frictional coefficient, u.

Excluding extreme conditions such as ice or snow, the lower frictional co-efficients occur under wet conditions due to the lubricating effect of the water film between tyres and road. It is with the measurement of these lower and, therefore, more critical co-efficients that this article is concerned.

There are three main methods of measurement; the 'sideway force', the 'locked wheel' and the 'portable skid resistance tester' methods, all involving the friction developed between the road surface and a skidding wheel or slider under standard conditions.

Sideway Force Method

This method involves the use of a special test vehicle which can track a smooth-tyred wheel inclined to the fore and aft axis of the vehicle. In motion the wheel side-slips, and the resulting thrust, perpendicular to the plane of the wheel, is measured and, together with the known vertical load on the wheel, provides a value of the frictional co-efficient termed the sideway force co-efficient. The vehicle used by the Road Research Laboratory for this work has a built in watering system and road lengths of up to two miles can be tested at one run.

Locked Wheel Method

This second method also requires a vehicle. A decelerometer is mounted in a smooth tyred car or van which is then driven over the surface to be tested. The brakes are applied so that the wheels lock for one second and the resulting deceleration, when expressed in terms of g, provides a measurement of the co-efficient of friction. This method requires that the road surface be wetted, and it can only be carried out on straight sections.

Portable Skid Resistance Tester

The sideway force method enables a comprehensive study to be made of a length of road but the vehicle required is a specialist item of apparatus. The locked wheel method can make use of an ordinary vehicle if fitted with smooth tyres but, in the absence of rain, requires a water cart and is restricted to straight test lengths. Also, to avoid accidents with other road users, it requires adequate traffic control. To overcome these difficulties the Road Research Laboratory have developed the portable tester illustrated in Fig. 1.

Basically, the tester consists of a simple pendulum free to swing through 180° below a horizontal bar. The free end of the pendulum is weighted and carries a spring-loaded rubber shoe. On rotation the pendulum carries with it a tell-tale pointer which registers the maximum deflection. The horizontal bar which contains the pivot of the pendulum can be raised or lowered to suit the road conditions. At one end it has a spring release to hold the pendulum in the raised position. To the other end is fixed a graduated scale. The whole apparatus is mounted on a rigid base containing a built-in level bubble and sits on three levelling screws.

In the raised position the pendulum contains potential energy. If the pendulum is released, and allowed to swing unhindered, all this energy (excluding allowable resistances) is converted into rotational kinetic energy and, after passing the vertical position, is converted back to potential energy at the end of the swing. If, however, during its swing the rubber shoe of the pendulum slides on a rough surface, some of the kinetic energy is used in overcoming the frictional resistance and is lost to the pendulum. Accordingly, it will not rise so high at the end of its swing and, by suitably calibrating the scale, the amount of energy lost can be made to indicate the frictional co-efficient (termed the skid resistance) direct.

In use the apparatus is adjusted to conform to certain standard conditions, the main one being the length of road surface over which the rubber shoe will slide. The road surface is brushed and wetted over this short length and the temperature at surface level recorded. The pendulum is allowed to fall by operating the spring release and the maximum swing is indicated by the tell-tale pointer which registers the skidding resistance on the calibrated scale. This procedure is repeated and the mean of five successive readings recorded provided they do not differ by more than three units. If the range is

TABLE I
Skid-Resistance Pendulum

Location: Priory Road, nr. Junction with Bristol Road, Edgbaston, Birmingham. *Weather:* Dry with no recent rain.

Date	*Section*	*Test track distance from kerb*	*Surface Texture*	*Temp. Surface °C.*	*Skid-Resistance*						*Remarks*
					Mean readings at individual locations					*Mean Value*	
					1	2	3	4	5		
24.1.61	Priory Road-Eastbound	2 ft. 6 in.	Medium	3	66	61	70	67	72	67	Individual
	traffic lane between de-	5 ft. 0 in.	Medium	3	66	65	66	65	67	66	locations at
	tection pad and stop line	6 ft. 0 in.	Medium	3	70	70	70	71	70	70	22 ft. intervals

greater, the test is repeated until three successive readings are the same when this value is recorded. Measurements in this fashion are taken at five to 10 yard intervals along the length of road being tested, and the mean of the recorded resistances for each interval will give a representative value of the skidding resistance along the test length. Table I lists some typical results.

Surface Texture

As opposed to the sideway force method and the locked wheel method, which as described use smooth tyres, the characteristics of the portable tester are so arranged that the skidding resistance measured with it is representative of the frictional co-efficient developed between a *patterned* tyre and a wet road surface. Basically, under wet conditions, the effect of a patterned tyre is to provide drainage paths which assist in the dispersion of the lubricating water film. With a coarse open textured surface, the surface itself provides adequate drainage and there is little difference in the effectiveness of smooth or patterned tyres. With fine textured surfaces, drainage must mainly be by way of the tyre tread and, accordingly, the skidding resistance measured by the portable tester, being representative of a patterned tyre, may give higher values than tests carried out under the more critical smooth tyred conditions. Medium textured surfaces will have effects somewhere between those of the coarse and fine textures.

In interpreting the skidding resistance measurements, therefore, it is necessary to have some idea of the surface texture and a description should be included in the records.

The tester records the skidding resistance which would be experienced by the road user at the time of the test. However, it is known that the skidding resistance varies with temperature and also with season. In general, resistance increases with decrease in temperature and, in a way not fully accounted for by temperature changes, is usually higher in winter than summer. (Road Research Technical Paper No. 43). For comparison purposes, and to help in interpretation, the record should, therefore, include details of the surface temperature and the date on which the measurement was made.

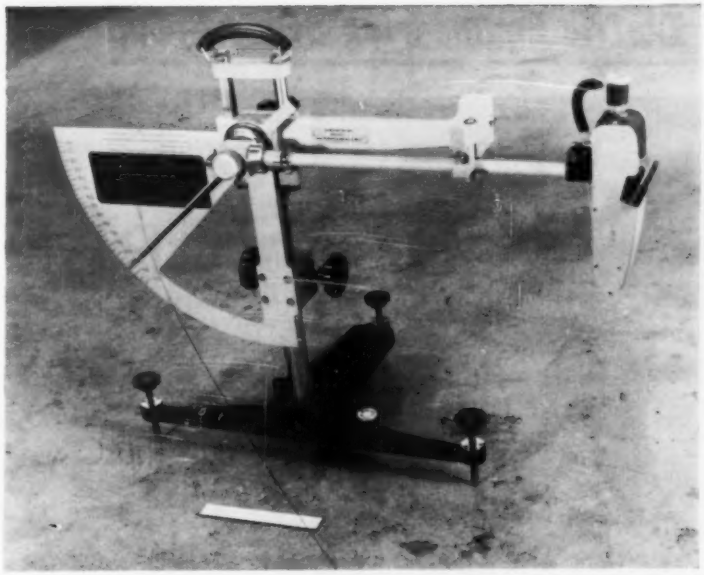

Fig. 1. Portable Skid Resistance Tester.

Different conditions of road layout and traffic give rise to different acceleration/deceleration rates and, therefore, different friction requirements. A knowledge of these requirements will enable an engineer to make best use of the available materials. Table II tabulates values suggested by the Road Research Laboratory.

Conclusion

The portable skid resistance tester provides a ready method of determining the skid resistance of a road surface. Its use, together with a knowledge of site conditions, will reveal early any accident potential from a skidding point of view and enable remedial measures to be taken.

This completes the present series on 'Instruments for Traffic Engineers'.

TABLE II

Type of Site	*Suggested minimum sideway force co-efficient on wet surface at* 30 *m.p.h. with smooth tyre*	*Suggested minimum skid-resistance on wet surface (See note below).*
'Difficult' sites such as: 1. Roundabouts. 2. Curves with radius less than 500 ft. on derestricted roads. 3. Gradients 1 in 20 or steeper, longer than 100 yds. 4. Approach to traffic lights on derestricted roads.	0.6	65
Sites neither 'difficult' nor 'easy'.	0.5	55
'Easy' sites such as mainly straight roads with easy gradients and curves and without junctions and free from any features such as mixed traffic especially liable to create conditions of emergency.	0.4	45

Note: On roads with fine textured surfaces smooth tyred vehicles may find the suggested skid resistances inadequate and reference should be made to accident studies for indications of skidding difficulties under wet conditions.
(Table based on C. G. Giles' 'Skidding and the Skid-resisting Properties of Roads'. J. Inst. H. E. Vol. VI (1959) p. 202 and 'Road Research 1957' D.S.I.R., H.M.S.O. London 1959 p. 30 *et alia.*).

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Traffic Engineering Study Group

PEDESTRIAN SUBWAYS

At a meeting of the Institution of Civil Engineers Traffic Engineering Study Group on February 16, 1961, a discussion took place on 'The use of pedestrian subways in urban traffic areas'. The joint paper submitted by L. A. Laffan, B.Sc. (Eng.) (Head of Traffic Group, Engineer's Department, London County Council), and R. A. Wright, M.A., A.M.Inst.T. (General Assistant to the Traffic Manager, British Railways) is printed below, with a brief report of the discussion that followed its presentation.

Fig. 1 Saturation flow in a London Transport subway.

THE pedestrian presents a major problem in urban traffic engineering owing to both his vulnerability and his slowness. His vulnerability means that should he come into collision with a vehicle travelling at say 15 m.p.h., he may suffer serious injury or even death although the combined speed of the colliding parties is only 18 m.p.h. In the event of two vehicles colliding at such low combined speed, the result would be, in all probability, damage only. His slowness means that his occupation of a section of highway is, for all his small size, greater than that of a vehicle considerably larger in area. Relatively small numbers of pedestrians using an uncontrolled crossing, a zebra crossing for instance, can reduce the capacity of a street by as much as 33 per cent.

The universal tendency towards urbanization is resulting in the pedestrian problem increasing at a rate comparable with the growth of vehicular traffic and it reaches its peak in the neighbourhood of the termini of the several systems of public transport. In London, the greatest concentration of pedestrians is believed to be at London Bridge Station, where during the peak morning hour more than 40,000 passengers are discharged into the road system around the station. Almost all have to cross a fairly heavily trafficked street soon after leaving the station, and the greater part of them cross Duke Street Hill where they bring traffic to a virtual standstill.

Possible Solutions

About one-third of the personal injury accidents in London involve pedestrians and it is therefore apparent that steps must be taken to protect them. These include:

(i) The zebra crossing.
(i) The light controlled crossing.
(iii) The introduction of a pedestrian phase into the cycle of a traffic signals system.
(iv) Grade separation from vehicles either by a subway or by a footpath.

Where traffic is controlled manually by a police officer, he will, almost certainly, provide pedestrians with the equivalent of (iii). That the first three of these systems are far from fool-proof is evidenced by the following figures for the Metropolitan Police District for 1959:

TABLE I

Type of Crossing	*Deaths*	*Injuries*
Zebra	36	1,689
Light Controlled	20	826
Police Controlled	—	86

Separate figures are not readily available for signal controlled intersections where a pedestrian phase is incorporated in the cycle. Outside the inevitable danger arising from turning traffic, however, the fact that during 1959 there were 1,616 prosecutions for disobeying a traffic sign or signal indicates that this device can, by no means, be regarded as 100 per cent safe.

Grade Separation

The figures given in the preceding paragraph make it clear, it is thought, that the fourth of our alternatives, grade separation, is the only one which will provide the pedestrian with complete protection from collision with vehicles. Note that it is not claimed that even this device will protect him from accident—he will, in all probability still contrive to fall down the steps and to find even more ingenious ways of coming to harm. Two methods of achieving grade separation for pedestrians are available:

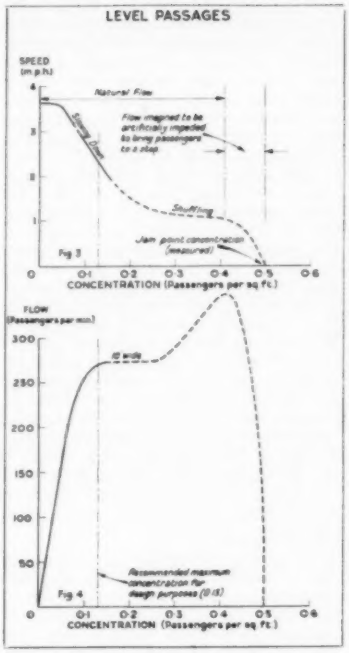

Fig. 2. Passenger flow plotted for level passages.

the over-bridge, and the subway.

At first glance the over-bridge would seem to be the ideal solution, the structure is light and cheap and modern techniques would be capable of producing a design which even the Fine Arts commission would find it difficult to fault. With a minimum of below ground work there would be little interference with the plant of the public utilities. The structure has, however, the great defect that it involves too much climbing and descending. The minimum practicable vertical clearance under a road bridge is 16 ft. 6 in. which means that the deck must be something in the order of 18 ft. or more above pavement level. As a subway floor has only to be some 12 ft. below pavement level, the extra 50 per cent of stairs is no light matter. Moreover, the modern tendency is to demand ramped access to grade separation structures so that, at a maximum permissible gradient of 1 in 12, the extra area required for a ramp up to a bridge, as compared with a ramp down to a subway, can be a serious and, possibly, expensive matter. There are situations, London Bridge Station is a notable one, where the two ends of an overbridge can be at footpath level with the road to be crossed some 20 ft. lower. This is obviously exceptional, however, and in all other cases resort must be made to the subway.

On theoretical grounds it is difficult to fault the subway but, in practice, its cost may rise to astronomical levels which make its construction a matter requiring the greatest deliberation. Some of the causes of this high cost are:

(i) The Metropolitan and District Railways run just below the surface of many of London's more important streets. The overall depth of their tunnels is too great to allow the subway to pass under them. The only alternative is to lower the tunnels to permit the subway to go over them. The potential cost of this operation needs no comment.

(ii) Where grade separation of several streams of vehicles is required and has to be achieved by means of an underpass, the underpass itself constitutes a barrier to subways at right angles to its longitudinal axis. The barrier can only be overcome by lowering the underpass some 10 ft. As the approach gradients should be in the order of 1 in 20, this means lengthening the structure by some 400 ft. Outside the resulting increase in works cost, this would mean the acquisition of some 25,000 to 30,000 sq. ft. of extra property, no small matter at current urban property rates.

(iii) In London, and presumably in most other large cities, the concentrations of plant of the public utilities companies under the pavement can be very intense. The construction of subways can involve this plant in considerable disturbance and there is one case on record in London where it is estimated that the construction of a single subway would involve alterations in plant to the tune of £600,000. This is, admittedly, an extreme case but it gives a measure of the problem.

(iv) Sewers frequently need diversion or regrading.

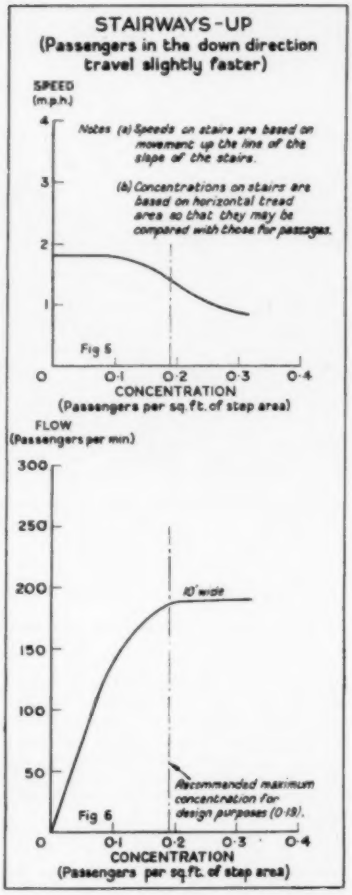
STAIRWAYS-UP
(Passengers in the down direction travel slightly faster)
SPEED (m.p.h.)
Notes (a) Speeds on stairs are based on movement up the line of the slope of the stairs.
(b) Concentrations on stairs are based on horizontal tread area so that they may be compared with those for passages.
Fig 5
CONCENTRATION (Passengers per sq. ft. of step area)
FLOW (Passengers per min.)
10' wide
Recommended maximum concentration for design purposes (0·13).
Fig 6
CONCENTRATION (Passengers per sq. ft. of step area)

Fig. 3. Passenger flow plotted for stairways.

In spite of these problems, however, it would appear that there is no entirely satisfactory alternative to the subway and the engineer must endeavour, by intelligent design, to keep these adverse factors to a minimum.

Subway Layout and Use

The typical British citizen is convinced that he has an inherent right to first call on the use of the highway even at the risk of his life and, if a subway layout involves him in any relative increase in journey distance, he will insist on the exercise of that right. It is essential, therefore, that any attempt to design a subway layout should be preceded by a pedestrian survey. As will be seen later, the information gained from the survey will also be required in the design of the subways themselves. Having ascertained the major desire lines of the pedestrians, the subways should then follow these lines with as little deviation as possible. This will, generally speaking, require the construction of double entrances and the survey should convey the additional information as to whether or not there is a sufficient proportion of the very young and the very old to justify the provision of ramped entrances as distinct from stairs.

Even where subways are direct and convenient they will be but little used

TABLE II

Route	*Journey Time*						*Percentage Users*
	Subway	*Surface*					
		Min.		*Max.*		*Average*	
	m. s.	*m.*	*s.*	*m.*	*s.*	*m.*	*s.*	
Westminster Bridge to Parliament Square	2 19	2	24	3	8	2	40	7
Across Victoria Embankment	1 0		51	1	29	1	4	25

TABLE III

Type of footway	*Free flow speed in empty passage or stair*	*Suggested maximum flow for design purposes. Persons per ft. width per minute*	*Concentration persons per sq. ft. for design flow*	*Shuffle speed*
	m.p.h.			*m.p.h.*
Level Subway	3.6	27	.13	1.1
Upward Stairs	1.8	19	.16	Not
Downward Stairs	2.2	21	.15	Observed

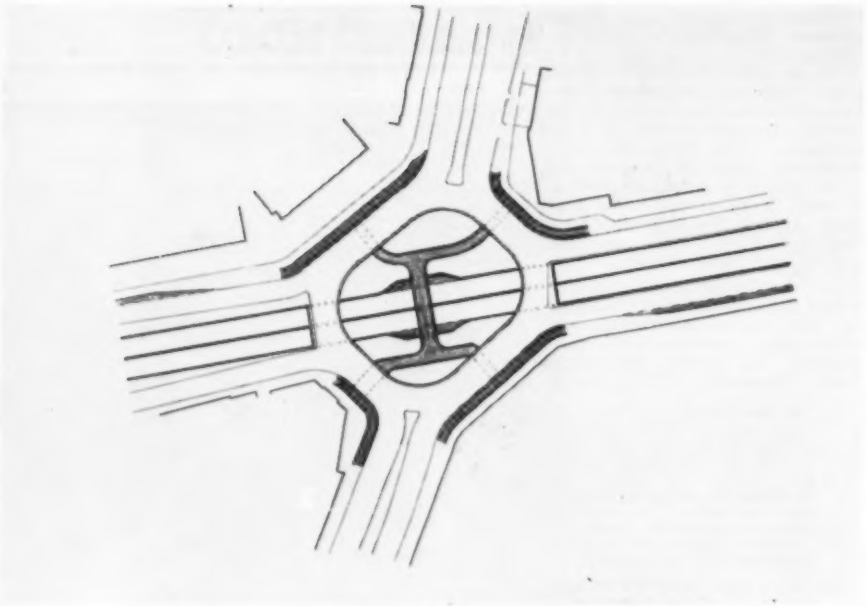

Fig. 4. A diagram of a lowered underpass illustrating the Birmingham idea.

by local residents, although in London visitors do seem to be alarmed by the density of the traffic and consequently appear more willing to use the subway. Some observations have been made on the group of subways under the Victoria Embankment and Bridge Street and are given in Table II.

The observations in Table II were made on a summer day, when large numbers of tourists parade up and down Bridge Street and pass on to Westminster Bridge for the view of the Houses of Parliament. It was observed that most of the subway users had cameras hung round their necks. It would therefore seem that the generality of the populace must be compelled into subways by the liberal use of guard rails. Furthermore, it is obvious that subways which are gloomy brick-lined vaults coated with dingy whitewash and are poorly lighted will deter prospective users. In direct contrast is the Piccadilly complex of subways with its bright lights, shops and other attractions. These subways are certainly well patronized, but movements in them are so complicated that it is difficult to ascertain to what extent the patrons are merely crossing the road, and to what extent they are entering or leaving the underground railway station. The device of using subways for the dual purpose of crossing the road and giving access to underground conveniences is not, in the opinion of the writers, generally desirable. The use of escalators or travolators to encourage the use of subways is frequently mooted, but the question of bearing the cost of maintenance and operation has still to be answered. It is also possible that the maintenance of escalators exposed to all weathers would present mechanical difficulties.

Design of Footways

The data that follows would be equally applicable to over-bridges or subways but the authors are in agreement that the subway is the more acceptable solution of the problem.

In considering the habits and mode of walking adopted by pedestrians, a series of observations were made with the object of assisting in the proper design of railway stations from the point of view of passengers using subways, ramps and stairways. It is thought that it can be accepted that results which hold good for walking railway passengers are valid for ordinary pedestrians with the exception of special factors involving perambulators.

To understand the background to the results, it is necessary to consider the method by which the observations were made. It involved the use of two observers (each with a stopwatch) who, at the start, were a measured distance apart. At a given signal both observers started their stopwatches. The upstream observer immediately joined the stream of pedestrians moving in the subway and walked with them at their speed until he reached the other observer at which time both observers stopped their watches. In the meantime the stationary observer counted all the persons passing him between the time of starting his watch and the moving observer reaching him. In this way the total number of persons in a given area can be obtained as well as the time of the movement. Thus the concentration of persons in the stream (persons per square foot) can be obtained, the speed of movement, and the flow in persons per minute. Graphs were then plotted of speed against concentration (pedestrian per square foot) and, as might be expected, speed fell with increasing concentration. When the flow in persons per minute was plotted against concentration for passages of various widths it was noticed that, over a certain range, speed and concentration compensated each other in such a manner that the flow remained constant.

Observation Results

By studying the results for passages of various widths, it was noticed that the maximum capacity was proportional to the width above a minimum width of four feet. Below this width of four feet the maximum flow was influenced by persons walking in 'lanes' associated with the width across the shoulders.

Similar relationships were observed for stairways up and down although, of course, the speeds and flows were less than for level passageways. The results may be summarized in Table III.

As far as escalators are concerned, the standard type in use on London Transport have a floor tread width of 3 ft. 6 in. and, moving at a speed of 140 feet per minute at an inclination of 30° to the horizontal, the maximum flow is about 130 persons per minute.

The effect of two-way flow in the same footway and the effects of other constrictions such as bends, corners, and inclines were also studied, but the results obtained were so frequently influenced by other extraneous circumstances that reliable conclusions were difficult to draw.

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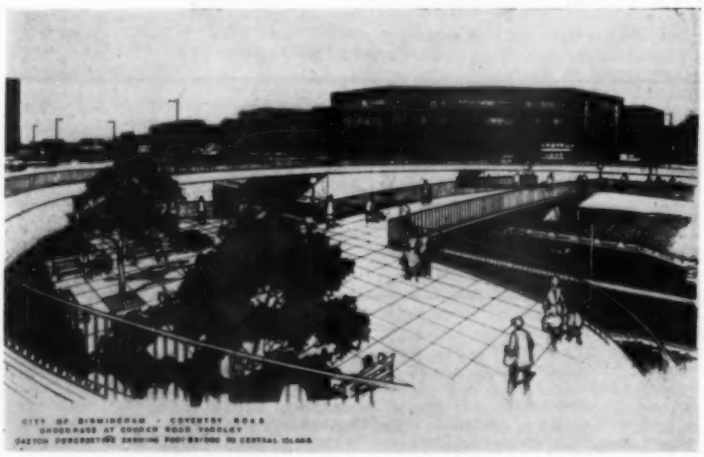

Fig. 5. Perspective drawing of the Birmingham idea.

LONDON AIRPORT'S PROBLEM

by FRANK BESWICK

Former Parliamentary Secretary, Ministry of Civil Aviation

Fig. 1. Central Terminal, London Airport showing one of the car parks.

TRAFFIC control problems for modern airports relate not only to the separation of aircraft in the sky and their safe take-off and landing. There is also a very considerable question of regulating road traffic. Though possibly not widely recognized, the special difficulties can be readily appreciated once one considers the factors involved.

In the first place the volume of traffic to and from a busy airport, particularly at peak periods, would constitute a traffic problem in any area of similar size. And every vehicle visiting an airport needs to stop and probably to park for a period of a few minutes at least, and maybe for a matter of days. Moreover, the area available for both moving and parked vehicles, which is limited enough in the first place, tends to become even more restricted as the use of the airport grows and the demand for additional buildings becomes imperative.

In the case of London (Heathrow) Airport, the conditions include a unique feature, for the whole of the incoming and outgoing traffic to the central terminal area must pass through one tunnel. Apart from this single underground artery there is no access to the central area—except by crossing a runway at some point.

The first calculation to be made when planning the control of surface traffic is the growth of aircraft movements and the consequent terminal facilities. The growth at the London group of airports, after the exceptionally rapid development immediately following the war, has meant an approximate doubling every five years. The factors which have influenced this growth—the development of larger, faster, more economical and more reliable aircraft, the reduction of fares in real money terms, and the general economic advance of the country—are assumed to be continuing. Whilst no doubt there are likely to be variations in the annual rate of growth, the estimates for London for the future, based upon past experience, are as follows:

LONDON AREA TRAFFIC

	Terminal passengers	*Aircraft movements*
1955 (actual)	2,871,000	109,022
1960 ,,	5,800,000	157,000
1965 (estd.)	9,000,000	175,000-195,000
1970 ,,	14,000,000	230,000-250,000

When dealing with traffic flow at airports or at any other trouble spots, it is not, of course, the annual movement but the peak period which presents the problem. The airport planners therefore have used the concept of the 'Standard Busy Rate per hour,' (S.B.R.) This is based on the level equalled or exceeded on thirty separate hours during the year. The S.B.R. estimates for 1965 and 1970 at London (Heathrow) Airport are as follows:

	S.B.R. passenger movements
1960 (actual)	1,750
1965 (estimated)	2,800
1970 ,,	4,400

It is interesting to note that so far the actual figures of passenger movements have been very close to estimates, although it is true to say that the accuracy has resulted from an element of good fortune. Passenger capacity of London Airport was based on a calculated number of aircraft movements per hour which proved to be optimistic. On the other hand the growth in size of the individual aircraft has been much greater than was thought feasible. The result is, therefore, that rather fewer aircraft than were envisaged are bringing in the same number of passengers.

The absolute peak hour traffic is naturally somewhat higher than the S.B.R figure, and the forecast figures for 1965 and 1970 are: 3,800 passengers in 1965 and 6,000 in 1970.

The next step in planning is the interpretation of these passenger figures into vehicle movements. For the purpose of this interpretation, assumptions based upon past experience have been made. It is calculated that 60 per cent of the passengers use private or hired cars and taxis, and the remaining 40 per cent travel by airline coaches. Each car or taxi is estimated to carry an average of 1.5 passengers and each coach a load of 30. This gives us an S.B.R. figure for private cars of 640 in 1960; 1,120 in 1965; and 1,760 in 1970. The same assumptions give coach traffic figures to London Airport during the hour at S.B.R. departure times of 20 coaches in 1960; 25 in 1965; and 1,760 in 1970. In the case of private cars the flow leaving the airport at any given time is roughly the same as the incoming flow, regardless of the direction of aircraft movements. In the case of coach traffic, however, the operators endeavour to maintain something of a pool at the airport in order to avoid dead running, and consequently the number of coaches leaving the airport at a departure peak may be approximately half the number of incoming coaches.

Fig. 2. Interior view of the tunnel leading to the Central Terminal.

The absolute peak hour traffic flows forecast are, for cars, 1,400 by 1965 and 2,200 for 1970. The coach figures are 60 by 1965 and 90 by 1970.

There are factors which might well have upset completely some of these careful calculations. For example, the possibility of a rail link with London has been discussed from time to time and the idea of a mono-rail is again being pressed. Such a development would clearly have an impact upon road vehicle traffic movements. Also from time to time, there has been consideration of proposals to run more frequent public bus services, and another possibility has been a coach shuttle service from parking facilities outside the central terminal area. The old difficulty of the economics of operating coaches for comparatively brief peak periods has so far led to shelving these ideas. The only new development which now seems certain, as far as road travel to London Airport is concerned, is the proposed spur from the first section of the South Wales motor road. The present programme of road improvements provides for the completion of the first section of this motor road, with the connecting spur to the airport by 1963. This would mean motorway conditions from Chiswick to the Airport entrance and a road journey time between the West London Air Terminal and the airport of between 18 and 25 minutes.

Whatever improvement is effected upon the road system outside the airport, it will still be necessary for traffic to reach the Central Terminal by the one tunnel. With four lanes, and a capacity of 2,500 vehicles per hour, it is still expected that this artery will be adequate. Any limitation upon the growth of airports, it is estimated, will be imposed by the air traffic control and runway capacity. It should be added, however, that in addition to these estimated volumes of passenger traffic there will be all the movement of staff, freight vans and concessionaires' vehicles.

It has been noted that every vehicle travelling to the airport requires to park for some period of time. In fact, 80 per cent of passengers driving to the airport in their own cars, park for more than 48 hours. 60 per cent park for more than six days; and curiously enough a small minority who park their cars there appear to forget them altogether! At the present time there is a continuous demand for parking space for 3,000 vehicles, with a peak demand of 6,000; and it is estimated that by 1970 provision will have to be made for 14,000 car parking spaces.

This car parking problem has to be met within a restricted area in which there is a continually increasing demand for additional buildings. Today, there are available for parking approximately 830,000 square feet of ground, of which 240,000 square feet are allocated to staff and 590,000 square feet to passengers and operators. The available space has been steadily eroded by the erection of essential new buildings, and by 1970, when the new terminal buildings for the long-haul passengers and freight, and a probable second terminal building for the short-haul passengers, are in operation, the ground area for car parking will have further diminished to an approximate total of 580,000 square feet.

In these circumstances, a more intense use of available space appears to be imperative. Underground car parks are ruled out because of the very high water table and because of a network of services—cables, sewers, etc., that is highly complicated and cannot be disturbed. In such circumstances, the provision of multi-storey car parking

(*Concluded on page* 753)

Fig. 3. Northern entrance to the tunnel.

PROFILE *of a*

TRAFFIC ENGINEER

Professor W. Fisher Cassie

A BRIDGE BUILDER makes bridges, a road builder makes roads, and a Professor of Engineering makes engineers. This is roughly how Professor W. Fisher Cassie, Professor of Civil Engineering, University of Durham, describes his job: producing engineers and directing and carrying out investigations.

It is not just a happy accident that one of the prime movers in setting up this month's International Symposium at King's College, Newcastle upon Tyne (a constituent college of the University of Durham) on the most vital present day requirements of interrelating architecture, planning and traffic engineering in sheer urban survival is the man who, twenty years younger, saw the psychological and practical aspects of training structural engineers for the War. Himself in his thirties, he could sympathize with the young men, eager to go into the forces, but strove to keep them at the university till qualified and useful. This understanding of psychology, practicality, sheer knowledge of his subject and a passionate study of the academic means to the best ends has enabled him to stand firm in controversies that inevitably range round men of strong views and forceful activity.

He is very specially equipped for a university post. To begin with, there is his own scholastic achievement. Despite set-backs through illness, he took his B.Sc. (St. Andrews) in Civil Engineering before he was twenty. (He was born, incidentally, in Monifieth, a village near Dundee). He already had a general interest in bridges and roads, and went straightaway into the Dundee City Engineer's Office as junior to James Paton Watson, later the distinguished City Engineer of Plymouth, and already advanced for his time. Young Cassie assisted him in introducing the first roundabout in Scotland in 1926, where a radial road crossed a dual track ring road round Dundee. He was engaged in traffic engineering, therefore, in its earliest days in these islands. Then, under Hannay Thompson, he was seconded to harbour engineering, working on the borings for the so-far abortive Tay Road Bridge.

Before 1930, however, he was back at the University of St. Andrews, and came again under the influence of Professor Angus Fulton ('Daddy Fulton' to his students). Carrying out his first work in soil mechanics (although the name was then unknown) he worked on large shear box tests for his doctorate. Being awarded the first senior Sir James Caird Fellowship he studied at the University of Illinois (1930-31), working on research in vibrated concrete—then a new idea—and on triaxial tests on lightweight concrete. He was also by happy chance admitted at an 'early door', and studied moment distribution in Hardy Cross's own Department in the first year of its use. Lighter incidents in his American stay included being arrested on suspicion of being a Chicago gangster!

After a year at Queen's University, Belfast, he spent three years at University College, Cardiff, where he became Bronze Medallist of the Institution of Structural Engineers and secretary to a Welsh choral society—an unusual post for a Scotsman! In 1936 he reached London as Lecturer in Civil and Municipal Engineering at University College, only to find himself back in Wales in another three years, when his section was evacuated to University College, Swansea, and he and Dr. A. A. Fordham, for a year, ran the civil engineering activity for these two colleges.

The constant recollection of names, typical of men who are passionately centred in progress for its own sake, rather than on personal ambitions, is a feature of conversations with Professor Cassie. Not that he has any false sentiment. Part of his efficiency is his quiet awareness of the value of achievement, his own and others. Another trait is his gratitude for chances. He has derived pleasure from having been brought up in a musical environment, his father having been church organist for 25 years. More practically, he has scored because his father's profession was that of printer, so that his son was familiarized with proof correcting as he grew up, an immense advantage to his wide writings. These include, incidentally, two 'best sellers', 'Structural Analysis', and 'The Mechanics of Engineering Soils', the latter written with P. L. Capper and known as 'Capper and Cassie'.

In 1940 he moved to the Newcastle Division of the University of Durham (his seventh university institution in Scotland, U.S.A., Ireland, Wales and England). Here he has remained, transferring his allegiance to Newcastle. He moved up rapidly in the hierarchy, and in 1943, his became the task, as first Professor of Civil Engineering, to build up an activity that is not only known nation-wide, but is world famous. He has developed his Department on the basis of professional training for the undergraduate, linked with a strong post-graduate School. In two fields under his direction and encouragement the Department is especially well-known. Since 1949 public health engineering (especially research in trade wastes and river pollution) has been built up by P. C. G. Isaac, Reader in Public Engineering. Since 1952 highway and traffic engineering has also been a special field of research and post-graduate training under T. E. H. Williams, Rees Jeffreys Reader in Highway and Traffic Engineering.

Professor Cassie deplores the reluctance of British engineers to return to a university for post-graduate study, although many overseas engineers are sent here. 'We have assisted the, solution of the traffic problem in U.S.A. New Zealand, Australia and South Africa more than in this country'. He is also uneasy at the flow of his best graduates to Canada and U.S.A. 'This is a serious loss to the country—one we can ill afford. Far too large a proportion do not return'.

Professor Cassie has written the expected number of papers, has been distinguished by, and has, himself distinguished national and international institutions. He has also travelled widely on university and professional business. He was invited to assist the National University of Mexico in the setting up of its new civil engineering laboratory and spent a month within the limits of the University's brilliant architectural composition. He was a member of the Wilson Commission on Fourah Bay College, Sierra Leone (affiliated for nearly a century to the University of Durham). The Report of the Commission was followed by the grant to the College of a Royal Charter.

Professor Cassie's hobbies include photography and the study of the traditional ceremonial men's dances of England. He is recognized as one of the authorities on the rapper sword dance of the miners of Tyneside. He has, however, given up note-taking in shorthand in favour of modern methods and is seldom separated from his tape recorder.

Focus on
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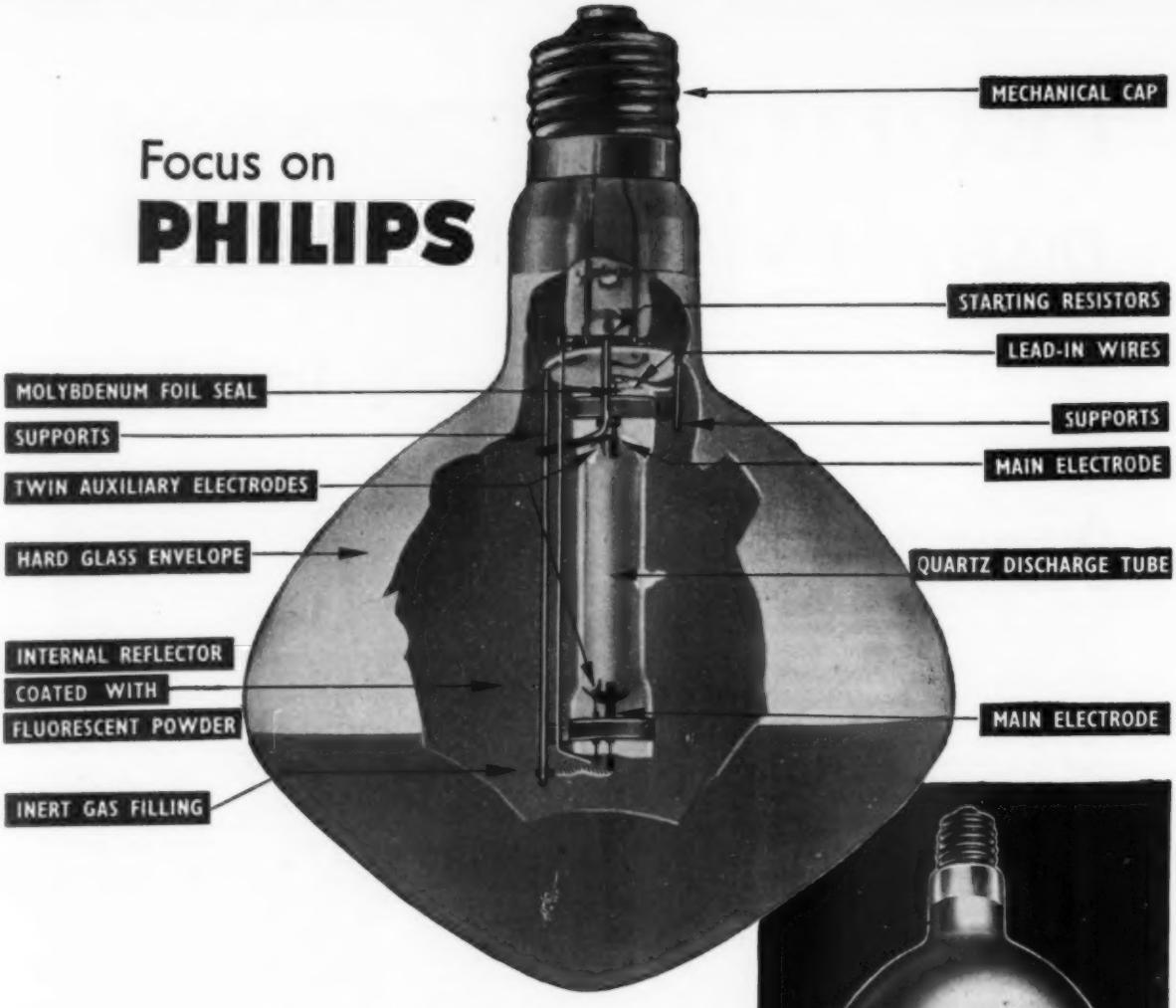

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Discharge Lamps for Street Lighting

by John Boud, B.A., *Philips Electrical Limited*

Fig. 1. Installation of Revo Helion Lanterns for mercury fluorescent lamps on Douglas Promenade, Isle of Man.

THERE are today a large number of light sources which can be used effectively in street lighting. There are tungsten filament lamps, fluorescent tubes, mercury lamps, mercury fluorescent (or 'colour-corrected' mercury) types, jacketed sodium and integral sodium lamps. Indeed, the variety available is sometimes the cause of complaint from the layman; and when the subject of uniformity arises most road users interpret this word in terms of lamp types rather than thinking that it refers to spacing, mounting height or surface brightness. The motorist certainly has some justification in objecting to frequent changes in colour and effect if they appear to be arbitrary. It would probably be undesirable psychologically, even if for no other reason, to have every street in the country lit by the same type of lamp, but there is a real case for some degree of rationalization.

One approach would be to think in terms of two types of lamp only. The monochromatic yellow sodium, the most efficient by far of all sources, would be used for main traffic routes; while in city centres, residential areas and wherever else a 'white' source with good colour properties is required the choice would be mercury fluorescent, with its combination of high efficiency and relatively small lamp size. This type might be used in addition at roundabouts, where the change from sodium would serve as the clearest conceivable indication of their location. A high central column carrying a large lantern with a number of high-wattage mercury fluorescent lamps would permit servicing to be carried out without interruption of the traffic flow.

Such a pattern for the nation's streetlighting seems additionally justified when the recent advances in these two discharge types are taken into consideration.

As one moves through the visible spectrum, the sensitivity of the eye varies considerably. From the threshold at the violet end the response of the retina increases through blue and green to reach a peak in the yellow; this is followed by a decrease through orange and light red to zero again at the boundary between deep red and the invisible infra-red. This means that if it were possible to convert a given quantity of electrical energy completely into visible light, the response of the eye would be greatest if the conversion were all into light of the peak yellow wavelengths, and since this response is the only measure of quantity of light this in turn would mean the highest possible efficiency.

It is fortunate that we have in sodium an element which emits from its excited vapour a light output almost entirely concentrated in two lines very close together in the yellow region. The sodium lamp seems almost to be the result of a benign Nature's conspiring to provide us with the materials for a very high efficiency light source.

As in any discharge lamp, optimum operation depends on the ideal conditions of temperature and pressure; this necessity has resulted in the outer cover which surrounds the discharge tube. In the traditional form of sodium lamp, the vacuum jacket is a separate cover which can be used for about five 'inners'. It needs replacing when the lamp 'burns red' and fails to run up to full output. The sodium lamp is essentially one for near horizontal operation, but even then there is a tendency for the sodium to migrate, to collect, that is, towards one end of the discharge tube. Some discouragement has, therefore, to be built into the lamp.

The difference between two methods which have been used is largely one of scale. The inner can be made of a type of glass which offers considerable frictional resistance to the movement of the metal, or the glass tube itself can be reticulated, as in the 'Bamboo' type of lamp, so that definite physical obstacles are provided. In each case, there are advantages and disadvantages. In the former, staining results so that the glass walls do not transmit all of the light emitted from the discharge, while in the latter, although non-staining glass can be used, the design does not allow

Fig. 2. High-wattage integral sodium lamps produce brilliantly clear seeing conditions on a stretch of the A8 near Glasgow.

quite the same efficiency as with the straight-walled lamp, and the light output is lower. The plain tube types have always had a higher efficiency initially and throughout life, and this has recently been boosted and the service life extended by the introduction of triple-coil electrodes. This, together with other improvements in gas and glass, has meant the appearance of a jacketed sodium lamp with a smooth inner which combines a higher efficiency than the Bamboo type with at least as great a reliability and better lumen maintenance. The production of the reticulated version has therefore ceased. The improved lamp is known simply as 'A-type'.

The most spectacular advances in sodium lamps recently have occurred of course in the integral types, and lamp manufacturers have spoken with pride of at last reaching three-figure efficiencies, that is, 100 lumens per watt. Although this enthusiasm is justified, one should perhaps be cautious in interpreting these figures, as the actual service wattage may differ appreciably from the nominal. The only guide for practical purposes is a statement of the light output of the source, and here of course the average-through-life figure means more than the initial or 100-hour output. The street lighting authority is, after all, interested principally in lumens per hundred foot, in the quantity of light actually being delivered. The U-tube integral sodium lamp of 200-watt rating with its dimpled construction now has an average-through-life output of 20,000 lumens. The dimples in the inner tube appear as repeated protrusions—the significant point being that they project outwards. This means that this type of construction is not possible in jacketed lamps where such projections would almost certainly receive blows when the inner was being slid into the jacket.

The function of the 'dimples' is mainly to provide a series of points at which the temperature is below that of the surrounding zone. The weight of metallic sodium present in a lamp is normally about a million times that vaporized in operation, but it is nevertheless important that when the lamp is switched off condensation occurs in a controlled way throughout the length of the discharge tube. The dimples ensure this, for their lower temperature means that condensation first occurs in them. This lowers the pressure in the immediate vicinity and there is a movement of vapour towards the dimple where it too condenses.

Integral sodium lamps are now available in the following ratings: 45, 60, 85, 140 and 200 watts. The last of these has no corresponding jacketed type and a special ballast has been produced in the form of a high-power-factor unit with built-in capacitor, but the other four ratings are electrically identical with the corresponding jacketed types and so can be used as immediate replacements working with completely standard control gear. Prediction is always dangerous, but one can be relatively confident in thinking that integral sodium lamps (type SOI/H) will become standard within the next few years, and that the use of separate vacuum jackets will tend to die out. A comparison of light output figures at once explains this trend.

Sodium lamps

Average-through-life lumen outputs

	SO/H	SOI/H
45w.	2,250	3,100
60w.	3,420	4,700
85w.	5,525	7,400
140w.	9,100	12,200
200w.	—	20,000

The mercury spectrum shows a much wider distribution than that of sodium; it consists of many more lines. Their wavelengths are not altered by normally possible changes in the pressure of the vapour through which the discharge is passing, but varying it does result in a change in the proportion of the total output which occurs in each line. In a tubular fluorescent lamp the mercury is at low pressure and very little visible light appears from the discharge itself. The bulk of the output lies in the ultra-violet region and the phosphor coating converts some of this into the spectrum required—usually a continuous spectrum within the visible range. The output of the lamp can be specified to the phosphor chemist.

In high pressure mercury lamps on the other hand, a much higher proportion of the energy appears in lines in the visible spectrum, and it is the production of these different conditions of temperature and pressure which accounts for the small size of the discharge tube.

Even at high pressure, however, the mercury spectrum is very deficient in light in the orange and red zones. Considerable energy is still appearing in the ultra-violet, and the solution to the problem of improving the colour rendering of the mercury lamp lies in coating the inside of the outer bulb with a special fluorescent powder which will absorb some of this otherwise wasted ultra-violet and produce the missing red light. This additional visible output balances the loss due to absorption in

Fig. 3. For the Class B street lighting in the Paignton U.D.C. area, 50-watt MBF/U lamps have replaced 100-watt tungsten. Increased light output has accompanied savings in consumption and maintenance costs.

the phosphor so that the high efficiency of the mercury source is maintained and the light output figures for mercury fluorescent or colour-corrected types (MBF/U) are the same as those for high pressure mercury lamps without this coating (MB/U). This principle has in essence been applied for over twenty years, but recently there have been marked refinements and improvements both in the initial percentage of the red addition and in the way this has been maintained throughout the long life of the lamps. Moreover, the total efficiencies and lumen maintenance show advances.

Mercury fluorescent lamps now come in seven ratings. For the 50, 80, 125, 250 and 400 watt sizes, the colour correction is due to an addition of more than 8½ per cent red light and the depreciation of this correction at the end of life is less than 1½ per cent. For the 700 and 1,000 watt ratings the 8 per cent red addition falls by only about 1 per cent at 5,000 hours.

Mercury fluorescent lamps are widely employed in new installations where efficiency and good colour rendering must go together, but they have a major application also in the modernization of existing tungsten street lighting schemes,

Mercury Fluorescent Lamps
Average-through-life lumen outputs

50w.	1,400
80w.	2,700
125w.	4,900
250w.	10,500
400w.	18,000
700w.	32,000
1,000w.	45,000

particularly those where the wattages are modest. Paignton Urban District provides an example. Here the class B street lighting followed a definite pattern of 15-foot high concrete columns at 120-foot spacing with totally enclosed lanterns. Until recently these housed 100-watt tungsten lamps. The 50-watt mercury fluorescent lamp has the same overall length, is slightly slimmer, has a greater light output, and a rated life, of course, of 5,000 hours. Some 900 of these lamps have now been installed in Paignton. Their low consumption, long life, and good colour qualities have persuaded this authority to use them as a complete substitution of all tungsten lamps of 100-watt and 150-watt ratings. This will mean in all a conversion of some 1,400 points.

Although they have not, as yet, been applied in this way in this country, there is a case for using the reflector mercury fluorescent lamp (MBFR/U) in groups on high columns for lighting important city centres, squares, and circuses. In these types, which are at the moment available in the 250- and 400-watt ratings, the phosphor coating is applied only to the internal reflector surface and not to the front of the bulb, through which the light emerges. They constitute powerful sources of 'white' light with built-in directional control. They are widely used in industry, and important railway termini are being relit with them. Wherever street lighting departs from the silhouette principle appropriate for traffic routes, and higher than standard illuminations are provided in something approaching area lighting terms, they have an obvious application.

Constant research and development means that electric lamps literally get better all the time. Efficiency, life, reliability, colour quality—all these things improve. The street lighting engineer can most readily take advantage of this technological progress by employing those advances which mean that his programme of new lamps for old can be carried out in existing lanterns and often with existing control gear.

PEDESTRIAN SUBWAYS

(*Concluded from page* 742).

Conclusions

(i) While the design data has proved very reliable for use in relatively short subways and passages, care is needed in interpreting it for use under more extensive conditions. It condemns all users to the same speed when conditions approach the maximum rate of flow and this is not acceptable generally.

(ii) It is extravagant to construct stairways and the adjoining level passageway of the same width, for either the stairs will be a bottleneck or the passageways will be under-utilized. In urban practice, this is frequently attended to by giving the subway dual entrances, but reference should be made to the pedestrian survey to check that the streams using the two staircases will not be out of balance by more than two to one. If this ratio is exceeded then one staircase will still be overcrowded.

The opening speaker in the discussion said it was paradoxical that although it was prudent, because it was safer and more efficient, to use a specified means of crossing roads, they were little used because there was no enforcement. This could be achieved either statutorily or by the exigencies of traffic. He fully agreed with the authors of the paper that the public considered they had the right to the road and he favoured legislation to require better pedestrian behaviour. Apart from imposing penalties, there were other means of persuading pedestrians to use subways:

(1) A wider use of guard rails.
(2) Introduction of much longer periods of time—two to three minutes—before the pedestrian traffic is allowed to cross at a controlled intersection.
(3) Greater use of escalators.

One speaker describing work undertaken in Birmingham said that lowering of an underpass was only necessary if the junction for cross and turning traffic was controlled by traffic lights.

In Birmingham, wherever possible, the cross and turning traffic was being dealt with by means of an island and if this island was of sufficient size, then the footways on the island could be ramped up from the subways, thus the bridge over the underpass could be at existing carriageway level. This is shown diagrammatically in Fig. 4 and it will be seen that the ramped walls to the subway approaches on the outer perimeter being immediately at the back of the kerb, act as pedestrian barriers. Fig. 5 shows a perspective drawing of the same idea and it was hoped that such islands would form attractive features.

The speaker also referred to what was being done in connection with new developments where the whole width of the footpath leading down to the pedestrian subway was ramped, the shops also following the ramp. These ramp walls also acted as pedestrian barriers and for the remainder of the length of this dual carriageway road an ornamental wall was being erected on the narrow central reserve, thus discouraging pedestrians from crossing at any point except at the subways. These are being constructed at about the same interval as permitted by the Ministry of Transport for surface pedestrian crossings in busy towns, i.e. 200 yards. The subways are being made attractive by having kiosks, showcases and sometimes shops. This principle of pedestrian segregation would apply to the main radial roads, the Middle Ring Road and the Inner Ring Road. It is considered that pedestrian segregation of this type gives greater value for money than any other part of the improvement schemes.

Another contributor, who had organized investigations of the behaviour of pedestrians, said that the simplest method employed had been that of timing pedestrians and comparing the time taken crossing roads and using subways and bridges. He described an experiment at a subway site on a busy arterial road, where a team of observers observed from roof tops of industrial buildings routes taken by pedestrians at the evening rush hour, whose paths were then traced on maps. It was found that before the construction of the subway 41 per cent of the people crossed at traffic lights, but a large number dodged through the traffic. After its construction, the total flow through the subway was very much greater than the 41 per cent who had previously crossed by the lights. Experiments at a further three sites showed that only about 70 per cent used a bridge but some 90 per cent used a subway where it took no longer than to cross at ground level.

Traffic Engineering Study Group

Full reports will appear in the May issue of the discussions on Instrumentation for Traffic Studies and Future Developments in Traffic Signals.

INDUSTRIAL NEWS AND INFORMATION . . .

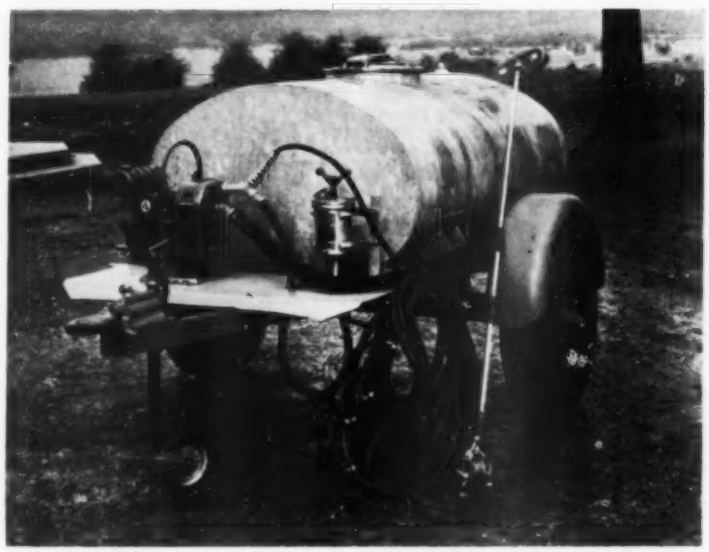
The largest installation of alloy street lighting columns ever undertaken in this country has just been completed: 665 have been erected in the Borough of Ilford, as part of a seven year plan, in which the Council intend to re-equip the entire street lighting system. The alloy columns, manufactured by Alf'd Miles Ltd., have been supplied and erected by Atlas Lighting Ltd. in 40 side streets designated as Group 'B' sites.

Alf'd Miles are a subsidiary of the Gloster Aircraft Co. Ltd., and many of the materials and techniques more usually associated with the specialized manufacture of aircraft have been utilized in the making of these columns. A virtually non-corrodable alloy is used, and a special welding technique enables Miles to construct the columns in one piece, and to eliminate the usual welding lines. Being non-corrodable, the alloy does not need painting although those at Ilford may be given a coat to fit in with the Council's general colour scheme. At the moment they still have the special finish given to them at the factory.

In this scheme, Atlas Lighting Ltd. have been responsible for supplying the columns and for fitting the lanterns, which are of post-top design incorporating 45 watt sodium lamps. They replace 60 watt tungsten lamps on cast iron posts.

T.E.C. 180 for further details

One of Ilford's new lighting columns.



The M1 sign washer.

A Versatile Sign Washer

With the advent of high speed Motorways came the need for very much larger road signs, to enable motorists to see their directions more easily and quickly than had hitherto been necessary. At the same time, it became more difficult to keep these signs in a condition clean enough for the motorist to understand their legends without distracting his attention from the road. To deal with this problem, a mechanical washer has been designed in a form which allows the machine to be used for other work.

Basically the M1 washer, as it is called, consists of a trailer mounted tank with 250 gallon capacity, a small petrol driven pump and the washing equipment. This whole unit may be mounted on any suitable self powered chassis, but in the interests of versatility and economy a trailer is considered by the manufacturers, J. S. Webber Ltd., to be more convenient. No costly vehicle is out of use when the washing equipment is not required and most municipal vehicles are capable of towing a trailer of the required size. The light weight of the trailer also has an advantage over lorry mounting in that it can travel over grass verges and central reserves with little damage. The simplicity of the basic equipment enables the M1 washer to be used for other work apart from sign washing. Examples of these are the washing of municipal vehicles, the spraying of liquid anti-freeze compounds on the roads in icy weather and spraying verges with weedkiller. The makers claim that for no great length of time need this machinery remain unused. Details of the trailer and its equipment are as follows:—

Trailer: A two-wheeled chassis with semi-eliptic spring suspension. Towing is by eye bolt and the unit has over-run brakes and parking brakes. An adjustable jockey wheel is fitted to simplify manhandling.

Tank: A 250 gallon tank is standard but other capacities are available. It is an all steel, welded construction and fitted with two cross baffles. A drainage outlet is fitted to allow complete emptying of the tank, which is filled through a manhole 1 ft. 3 in. x 9 in.

Pump and motors: An Auto Diesel B.1. self priming centrifugal pump is powered by a J.A.P. 34B two-stroke petrol engine. Also fitted as standard are a Listergent foam dispensing unit, two 20 yd. lengths of hose and a hand operated valve for controlling the flow of water/detergent. A soft brush and extension arm are also supplied as standard equipment.

In operation the M1 washer is handled by one man. Water from the tank is pumped through a Y-junction, one branch of which leads to the detergent dispenser and the other direct to the hand controlled valve at the end of 20 feet of hose. From the dispenser another hose is connected to the same valve which controls the mixture of clean water with detergent. From the mixing valve a short arm is connected to a soft bristled brush through which the water passes freely. Rinsing of the signs is carried out with the same brush, the mixture valve being turned to stop any flow of detergent but to allow clean water to continue flowing. By using this method of controlling the mixture of water and detergent, the whole washing operation can be completed with no time wasted by having to return to the pump or Listergent controls.

T.E.C. 181 for further details

Laying pitch fibre pipes.

Drainage for a Village

One of the problems facing the Council's Sanitary Surveyor was to keep the main road (A517), between Ashbourne and Belper in Derbyshire, open to traffic while laying main drains to the village of Holland Ward. The trenches for the sewers had to be narrow, since the road width was restricted and had to be backfilled quickly.

Taking less time than would have been possible with conventional materials, over 3,000 ft. of 6 in. pitch fibre pipe has been laid, together with 300 ft. of 4 in. pipe used for house connections. Because this type of pipe can be laid in a narrow trench (18 in. wide) the subsequent reinstatement of the road surface was simplified. Testing and backfilling was carried out quickly, keeping the cost of timbering to a minimum and enabling the A517 to be speedily re-opened to traffic. Due to bad weather and ground conditions the trenches were frequently water-logged but the job went ahead according to schedule. This drainage scheme was the first major installation of pipes made by The Key Engineering Co. Ltd. in Derbyshire and the Surveyor and contractors were well satisfied with the results.

T.E.C. 182 for further details

Champion 3D Crane

The photograph (right) shows an adaption of the Champion 3D crane made by Cornelly Equipment Co. Ltd. to work as a fully mobile unit fitted to an ex-W.D. six-wheeled lorry. The claimed advantages of fitting the crane on a lorry are great versatility, ability to service large sites on uneven ground, saving the cost of long runs of rail track plus the usual advantage of using a small tower crane. The Champion 3D crane which is available for immediate delivery, has a maximum lift of 1 ton.

T.E.C. 183 for further details

Mechanical Car Parking System

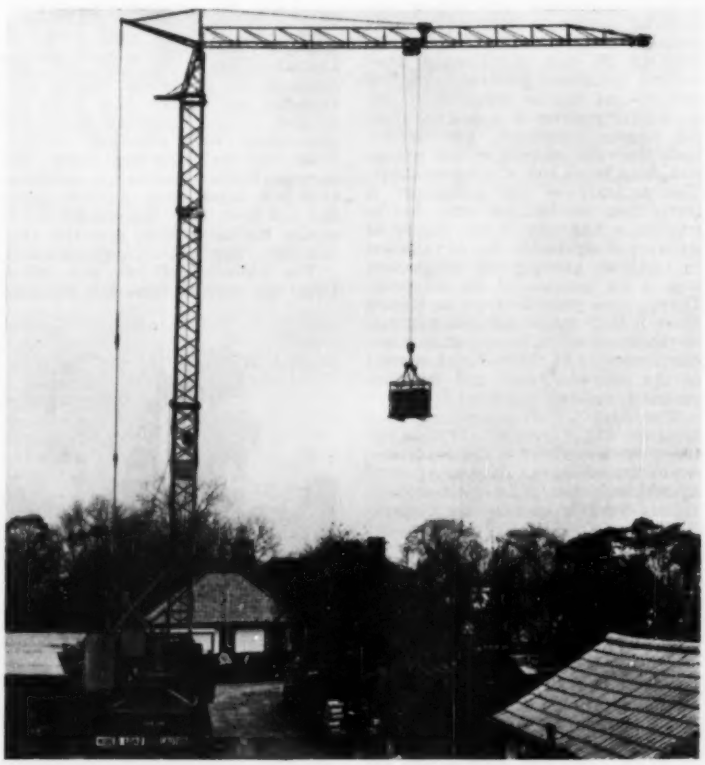
Messrs. Barry, Henry and Cook Ltd., of Aberdeen, have recently applied to take out patents for the 'Struben Sub-Street Parking System'. The system is readily adaptable to surface or multi-storey parking with ramps or lifts, but was primarily designed for use in the underground garage described below. It uses one transporting ferry only, costing well under £2,000, and no separate dollies. Since doors are not opened, cars can be parked very close together, nearly doubling the number of cars in a given space. At least 100 cars are normally served by one ferry, so that mechanically the cost per car space would, it is claimed, be not more than £20.

The method of parking a car is as follows: the car is driven into the ferry as directed, the wheel centred, brakes released, gears left in neutral and the doors locked. Ferry attendant locks wheels by stops or a moving guide rail, and propels the ferry by electric motor sideways along its alley-way to the required bay. Meanwhile a parking head, sliding on a ram, is positioned and a pair of rollers on it extended so as to push on the pair of car wheels nearer the ferry and propel the car into the bay. To unpark, the attendant pushes the working head further into the bay between the nearer pair of car wheels and extends the rollers behind them, withdrawing the ram to move the car back onto the ferry. He then runs the ferry back to the loading station where the driver gets into his car and drives off, up the exit ramp.

In the construction of the sub-street garage, entrance and exit ramps are provided at the sides of the street so that cars may leave and enter the streams of traffic with a minimum of interference. Hoods are built with glass side walls and perspex top, to do away with the impression of entering a dark tunnel. In the main structure, transverse beams of precast reinforced concrete in 21 ft. lengths are used. The maximum distance between the centres of these beams is 8 ft. Precast reinforced slabs are laid on these beams by a mobile crane, fed by its own transport which lays the slabs in position and moves forward over the slabs already laid. It will be possible to have the street in use again within about a fortnight of completing the excavation and side walls. The total excavation required is 9 ft. deep by 65 ft. 6 in. wide.

Because the public will not be allowed to enter the parking area, but will alight from their cars in the concourse in the centre, only 6 ft. 6 in. of head-room is provided. This is more than adequate, as no engines will run in the parking areas, there will be an exhaust fan at the far end and prism lighting (combined with ventilation) at intervals along the centre alley. The standard garage envisaged is for 200 cars, 100 on each side of the central alley at each end.

T.E.C. 184 for further details



The Champion 3D crane.

Please use the prepaid cards for the Reader Information Service. For further details of items mentioned in this journal, complete and return the card to us.

The Record H_2O meter.

Record Mark X H_2O Meter

This compact unit is designed to connect to an electrode in the mouth of the sand or fine aggregate hopper in concrete mixing plants, to indicate the moisture content of the aggregate or the variation of moisture content from one batch to another. The latest available model is fully transistorized, can be installed by any maintenance fitter without specialized knowledge, and the control unit can be mounted at any convenient position at a distance from the hopper controlled. The flexible leads from the unit are of low voltage and there is no risk of electric shock. The accuracy of the equipment is better than one-half per cent, but in practice a somewhat lesser degree of accuracy is obtainable due to variation in aggregate grading and compaction and to the location of the electrode. Despite these possible errors the Record Mark X H_2O meter will give guidance to the mixer operator, act as an automatic memory of the moisture content of the previous batch and will immediately indicate variations.

The Mark X H_2O meter is imported from the U.S.A. where it is manufactured by the makers of the Hydrobot, which is used for the automatic control of moisture content in batch mixers. Agents for this country are Cornelly Equipment Co. Ltd.

T.E.C. 185 for further details

Concrete Laying with Vögele

One of the main features of the Vögele Senior concrete spreader and the Vögele Senior concrete finisher is the interchangeability of spare parts; both machines have a strut chassis of the same design, reducing the quantity of spares required on site.

The spreader can be used for all types of laying work. The blade is turnable through 180° and travels in longitudinal and transverse directions at a speed up to 25 yd. per minute. The material is distributed quickly and evenly right up to the road forms, while the edging plates attached to both ends of the chassis ensure clean edges. By means of a simple hydraulic/mechanical control, all the working steps can be taken either at the same time or one after the other. Only one operator controls the machine and he has excellent visibility.

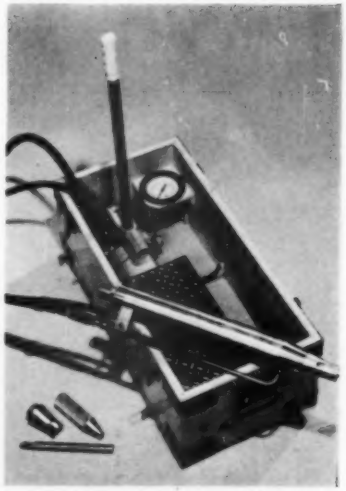
The finisher, built on an identical chassis, is equipped with a screed with adjustable length and inclination. The motion of the screed precompacts the spread concrete while the final compaction of the material is done by an oscillating beam of high periodicity. This beam was developed after many experiments and as a result of experience gained by road building contractors and from the personal experience of the manufacturers. Periodicity, amplitude and rate harmonize with each other in such a way that concrete consisting of very large aggregates can be compacted in only one pass. Vibration in the chassis frame is prevented by means of an elastic suspension in damping connectors. The oscillating beam is driven by vee belts running from the engine through oil immersed gears. There are eight different speeds for the operation and movement of the machine and a rubber-tyred transport unit can be fitted in a matter of minutes.

T.E.C. 186 for further details

Gifford-Udall Jacks

Ductube-Udall Ltd. have just announced the marketing of two new stressing sets, which have been developed to give improved speed and convenience when stressing Gifford-Udall tube and plate anchorages. The stressing kit incorporates 5 in. extension tube jack, hand pump, pressure gauge and jack tools, while the standard kit is similar but has a 10 in. extension tube jack with a larger, two stage hand pump.

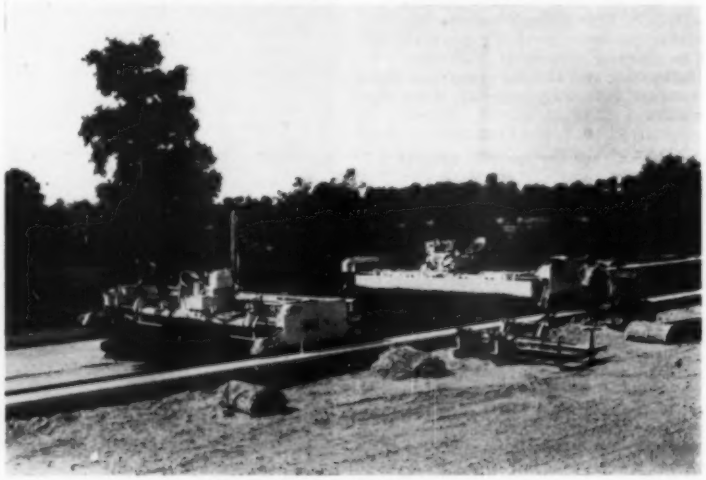
The Gifford-Udall tube jack, which forms the basis of these new stressing kits, may be used with Gifford-Udall 7° or 14° tube anchorages and with plate anchorages. The 5 in. tube jack is probably the smallest and lightest prestressing jack that has yet been produced —weighing less than 10 lb., it is only 14½ in. long and 2½ in. in diameter. The small size and light weight of the tube jack make it very much easier to apply to wires at close centres and for use in conditions of difficult access.



The Gifford-Udall prestressing kit.

When using the Gifford-Udall tube anchorage with 14° wedges, after the required extension has been achieved it is merely necessary for the operator to release the pressure. The final wedges are than automatically locked off in the anchorage and the jack retracts leaving the temporary wedges on the end of the wire. These are removed by hand and the jack is moved to another wire ready for the next stressing operation. When using the tube anchorage with 7° wedges or the plate anchorage, an alternative nose is fitted to the jack and the operation is identical except that the wedges in the final anchorage must be tapped home with a drift tool.

T.E.C. 187 for further details



The Vögele 'Senior' concrete train.

LETTERS TO THE EDITOR . . .

PARKING ENFORCEMENT

from John Houghton

Managing Director,
Parking Developments Ltd.

I was interested to read of the various functions performed by parking meters, described by Mr. Duff in his recent paper and reported by you on page 610 of your February issue.

It is only fair to the hard worked body of police and other parking enforcement officers, to point out that the parking meter performs none of these functions. It is the presence of an enforcement officer and the threat of sanctions that produces the results claimed. The meter is merely a revenue collecting and time recording device.

Certainly its physical presence encourages voluntary observation of time limits, but only for so long as it is apparent that enforcement is being carried out. Take away the policeman and the traffic warden, and the parking meter becomes useless.

This is not intended to denigrate the parking meter, which is a valuable tool in parking enforcement, and as is evidenced by the administration problem of the disc system (the Blue Zone) reduces considerably the number of enforcement officers required.

In America it is frequently recognized that the only effective way to control on-street parking is by using enforcement officials. Many towns are anticipating the introduction of parking meter schemes as the solution to their on-street parking problems, but in fact the solution already lies in their own hands, by the enforcement of existing legislation.

2-4 Cranmer Road,
London, S.W.9.

ELECTRO-MAGNETIC DEVICES

from L. G. R. Davies, A.M.I.Mun.E.

Recent reports in your journal of experimental work on magnetic traffic congestion detectors undertaken by the Road Research Laboratory at Crowthorne indicates official interest in the possible future applications of electronic and electro-mechanical devices in traffic control.

Assuming a continued rate of increase in vehicle usage in the London area, and in other congested cities in this country, the speedy introduction of new and effective palliative traffic measures appears to be of urgent importance in view of the period of time which must elapse in the promotion and execution of permanent measures.

In the field of palliative traffic engineering it is interesting to consider future possibilities in the use of electrical devices. The magnetic vehicle detector which will register the presence of stationary vehicles should have an immediate application in relieving locked conditions in traffic signal controlled junctions by the introduction of 'all-red' intervals. The device might also be applied in automatic volumetric traffic census recording, used in conjunction with a punched tape or magnetic tape recorder. It is reasonable to assume that an instrument of this type could be developed for the separate recording of classes of vehicles by division of physical length, with the advantage of subsequent rapid analysis of results.

Results of future traffic census may well indicate the existence of obvious 'tidal' traffic patterns, resulting in the establishment of measures to provide 'tidal' working on two-way roads and in reversible one-way systems.

There would be considerable scope in the inception of such measures for the development of electro-mechanical devices; for example, variable directional traffic separators and apparatus for variable traffic signing.

It is to be hoped that the very active electrical industry in this country may be encouraged to consider the assistance which might be provided to traffic engineers in this, at present, largely undeveloped field.

c/o Borough Engineer's Department,
Town Hall,
Lewisham,
London, S.E.6.

PARKING

(*Concluded from page* 744).

facilities seems inescapable and it cannot be long before the Minister makes a decision about inviting tenders for their construction.

Given the volume of traffic already indicated, and the area within which it must be contained, the problem is to ensure the smoothest flow. This problem is complicated by the different destinations of the vehicles which emerge into the confined central area from the one tunnel.

The central area is roughly a hexagon within the runways. On the operating side of the buildings are aircraft hardstandings, taxi-ways linking the different runways and hardstandings, the safety clearance zones, and the apron service roads. Within this hexagon there are the passenger terminal buildings, roads, vehicle parks, public enclosure, fuel installations and other services, and the control tower and administrative offices. Hitherto, the problem has been tackled by the comparatively simple means of enforcing a clockwise flow for all vehicles. Though simple to lay down, such a procedure has obvious disadvantages. It adds to the density of traffic in the initial stages of the flow; for example, the front of the short-haul terminal is congested by vehicles for other destinations situated further round the circulatory system.

The ideal solution is to segregate traffic at the airport entrance and to provide separate access roads for each destination, if necessary at different levels. This is the solution applied at New York's Idlewild Airport. Such an approach appears to be ruled out for London, however, simply because the land is not available within the central area. Nevertheless, the present clockwise circuit will scarcely suffice when the long-haul traffic, now catered for in temporary buildings on the north side of the airport, is transferred to the new terminal in the central area.

Proposals now being considered would break down the present circulatory system into four principal traffic patterns, feeding into the three passenger terminals and the one freight building. The other main destination is the administrative building, and this traffic would use the most convenient of these four systems. These proposals would involve the diversion of freight traffic at a point about half-way up to the entrance ramp leading from the tunnel, and it would be led off to the left and then back over the ramp to the freight building by means of a flyover.

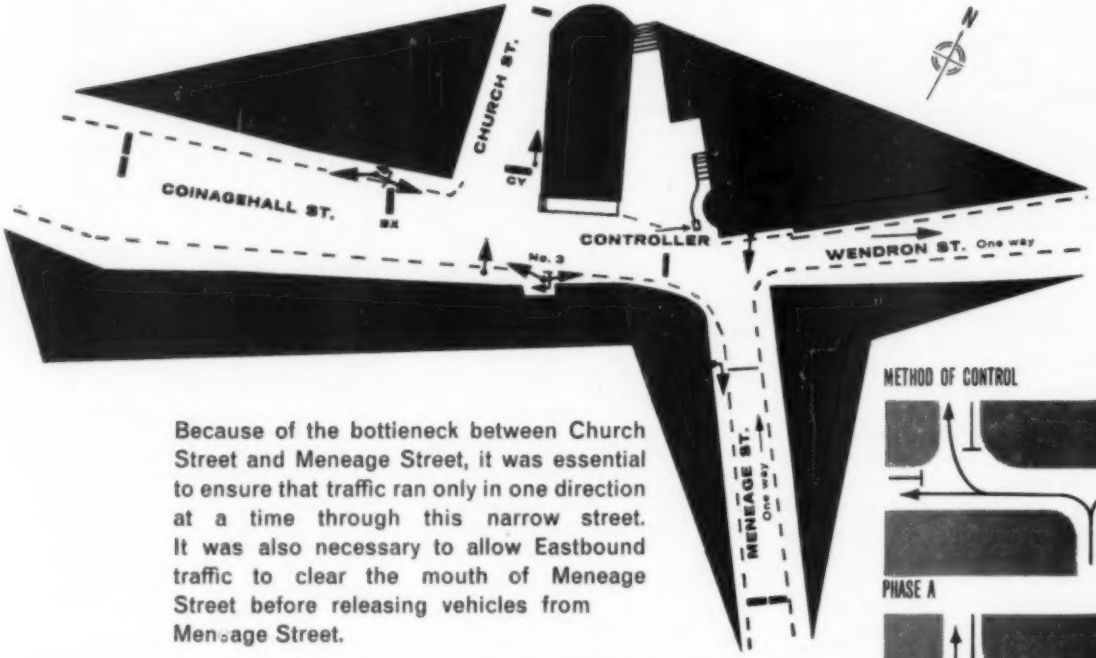
The short-haul passenger traffic would flow into their separate circulating systems. The difficulty would be to get the long-haul traffic over to the right and to the proposed new long-haul terminal. Failing a tunnel or another flyover, this right-hand diversion can be achieved only by interrupting the outgoing short-haul traffic. As both the tunnel and the flyover appear to be ruled out by lack of space, the answer seems to be traffic lights at the end of the tunnel ramp.

TEC445 *for further information*

AUTOFLEX in Cornwall

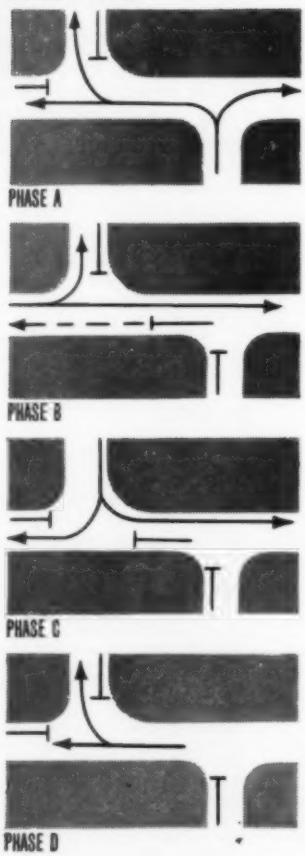
this is Helston . . .

where signals keep holiday traffic flowing smoothly



Because of the bottieneck between Church Street and Meneage Street, it was essential to ensure that traffic ran only in one direction at a time through this narrow street. It was also necessary to allow Eastbound traffic to clear the mouth of Meneage Street before releasing vehicles from Meneage Street.

METHOD OF CONTROL



Three Phases A, B and C ensure that traffic can only move in one direction at a time through the junction. Phase A does not commence immediately after Phase B or C, a short all red clearing period being given just to clear traffic at the Coinagehall Street-Church Street junction. Phase D is then given to avoid unnecessary delays to vehicles waiting at signal No. 3. The duration of Phase D depends on the previous operation of detector CY during Phase C or of detector BX during Phase B and is automatically adjusted by the controller to clear Eastbound traffic past Meneage Street before Phase A commences.

A straight ahead Green arrow filter allows Westbound vehicles to move during Phase B as there is no need to delay such traffic and it is desirable to keep the number of vehicles waiting at signal No. 3 to a minimum.

Sequent Amber's are given after Phase A and also when changing from Phase C to Phase B. An all red clearing period follows Phase B when changing to Phase C. These clearing periods are necessary to protect vehicles making the difficult turns at the junction of Coinagehall Street and Church Street.

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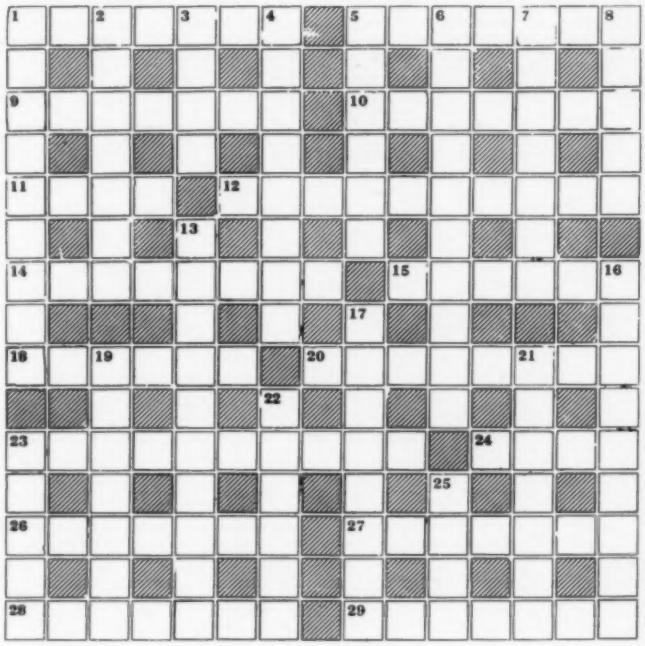
TRAFFIC ENGINEERING CROSSWORD NO. 10 by YEO

AMONG the clues and solutions will be found traffic engineering terms defined in the VOCABULARY OF TRAFFIC ENGINEERING TERMS published for *Traffic Engineering & Control* by Printerhall Ltd., and a copy of which is sent free to all subscribers to this journal. Copies are also available at 2s. 6d., post free, from the Circulation Manager, Traffic Engineering & Control, 34/40 Ludgate Hill, London, E.C.4. This completes the present series of Crosswords, but the solution to No. 10 will appear in the May issue.



Down

1. Hard Sweet (Anag.) (9)
2. Silent 'L' was given beans. (7)
3. This flag was not carried before cars. (4)
4. Serve as a soldier. (8)
5. A helicopter does. (6)
6. Spotted wild feline. (7, 3)
7. They cut the tape on roads. (7)
8. One who does may 21. (5)

SOLUTION TO CROSSWORD NO. 9

F	L	O	C	C	U	S	■	P	L	U	M	A	G	E
E	■	D	■	L	■	I	■	E	■	N	■	D	■	A
W	I	D	G	E	O	N	■	R	A	S	H	E	R	S
A	■	L	■	M	■	F	■	I	■	C	■	L	■	E
N	E	A	P	■	A	U	T	O	G	R	A	P	H	S
D	■	N	■	T	■	L	■	D	■	E	■	H	■	■
F	R	E	E	H	O	L	D	■	R	E	L	I	E	F
A	■	■	■	E	■	Y	■	E	■	N	■	■	■	I
R	E	S	I	S	T	■	I	M	P	E	R	I	A	L
■	■	I	■	P	■	A	■	A	■	D	■	C	■	T
S	I	G	N	A	L	F	A	C	E	■	N	E	A	R
A	■	N	■	R	■	F	■	I	■	R	■	B	■	A
F	L	O	O	R	E	R	■	A	L	I	M	E	N	T
E	■	R	■	O	■	A	■	T	■	N	■	L	■	E
R	O	A	D	W	A	Y	■	E	R	G	A	T	E	S

Across

1. & 8. A Knight who wants to raise the God of Love. (7. 7)
9. He painted Alice. (7)
10. Couldn't love tin in this fashion. (7)
11. Curb. (4)
12. Not necessarily film fans. (4-5)
14. Er-Er. (8)
15. Scorches in Miltonian fashion. (6)
18. A kind of speed. (6)
20. Pertaining to Polynesia, Micronesia, Melanesia. (8)
23. Intersection of two streams in circumstances which preclude weaving. (7, 3)
24. Centenarian bird could blot out a signal. (4)
26. The end of 'O and D'? (7)
27. A raring—but not to go. (7)
28. The Third Man's Vienna was. (7)
29. Despatch fast non-stop. 7)

13. Not a disease caught in old transport—more likely from footlights. (5-5)
16. It does, unless you have them in your car. (3-6)
17. It can be right to have a cute car. (8)
19. South softly dart a bird. (7)
21. See 8 down. (7)
22. Adjusted to. (6)
23. What's this? Causes trouble on the roads. (5)
25. One-way movement between 'O' and 'D'. (4)

INDUSTRIAL NEWS

(*Concluded from page* 752)

Mobile Crane at Work

The Perry Bar railway bridge contract, which was awarded last autumn by the London Midland Region of British Railways to Tarmac Civil Engineering Ltd., recently reached an interesting stage. The main beams for the new bridge, approximately 42 ft. in length and weighing 8-9 tons each, have been placed in position by a 50 ton mobile crane. These beams, which are precast and prestressed, will form the deck to carry the western carriageway of Birmingham Corporation's Birchfield Road Development Scheme across the railway at this point. Mobile Lifting Services Ltd., another member of the Tarmac Group, supplied the crane.

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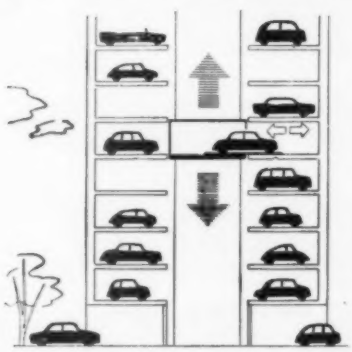

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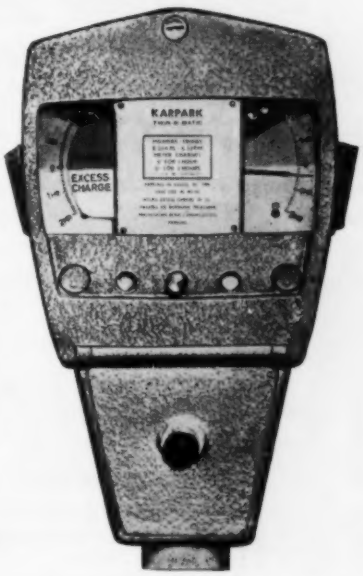

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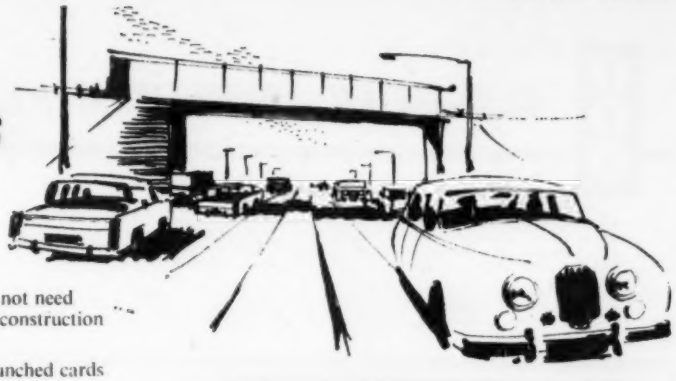

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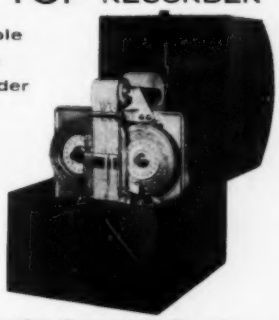

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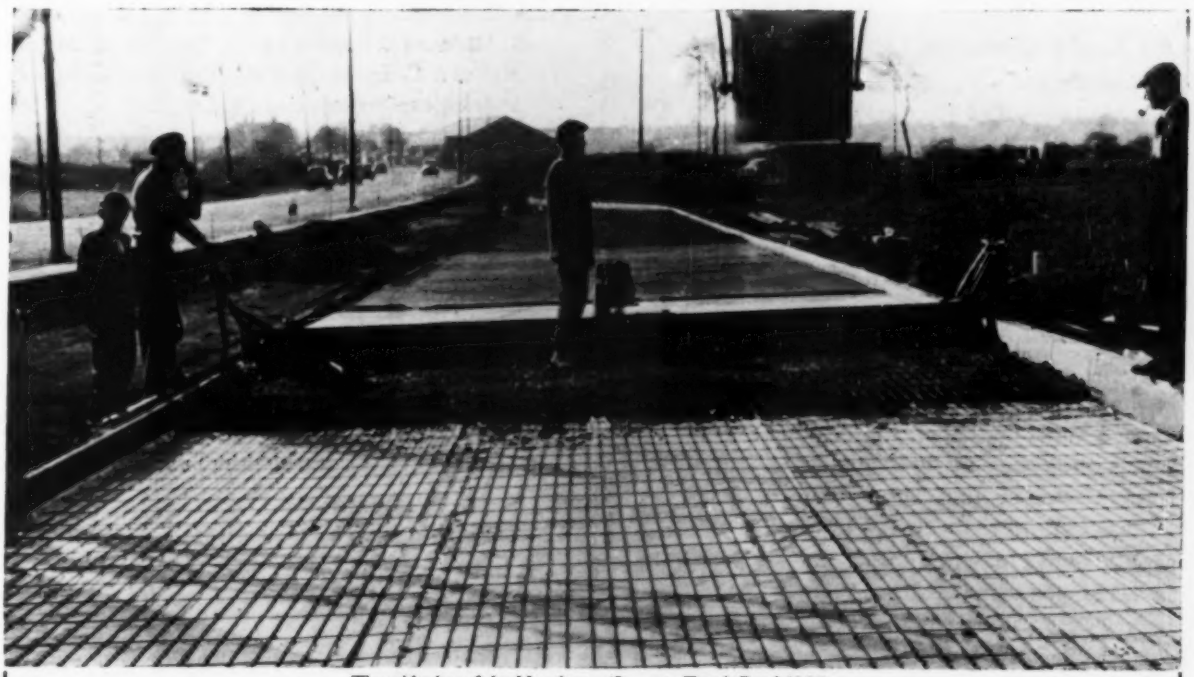

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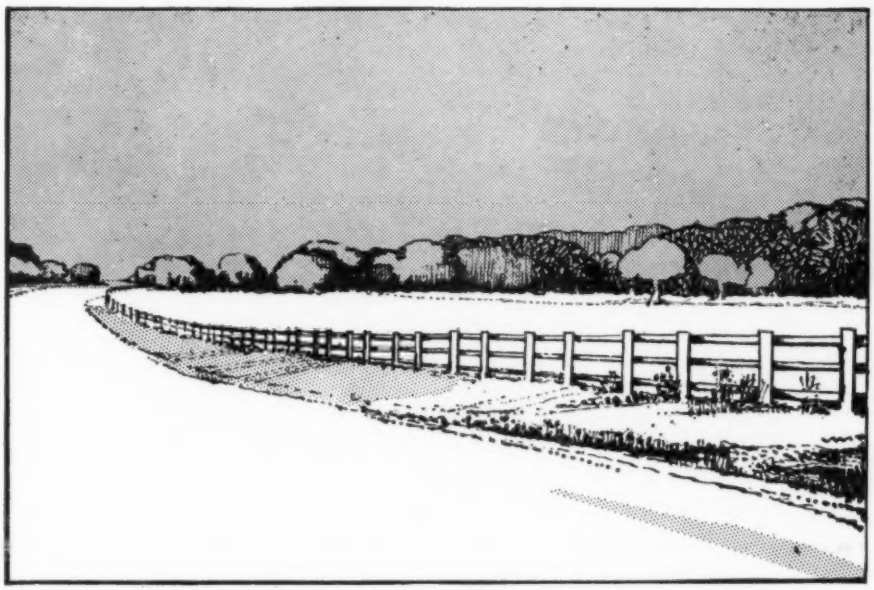

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